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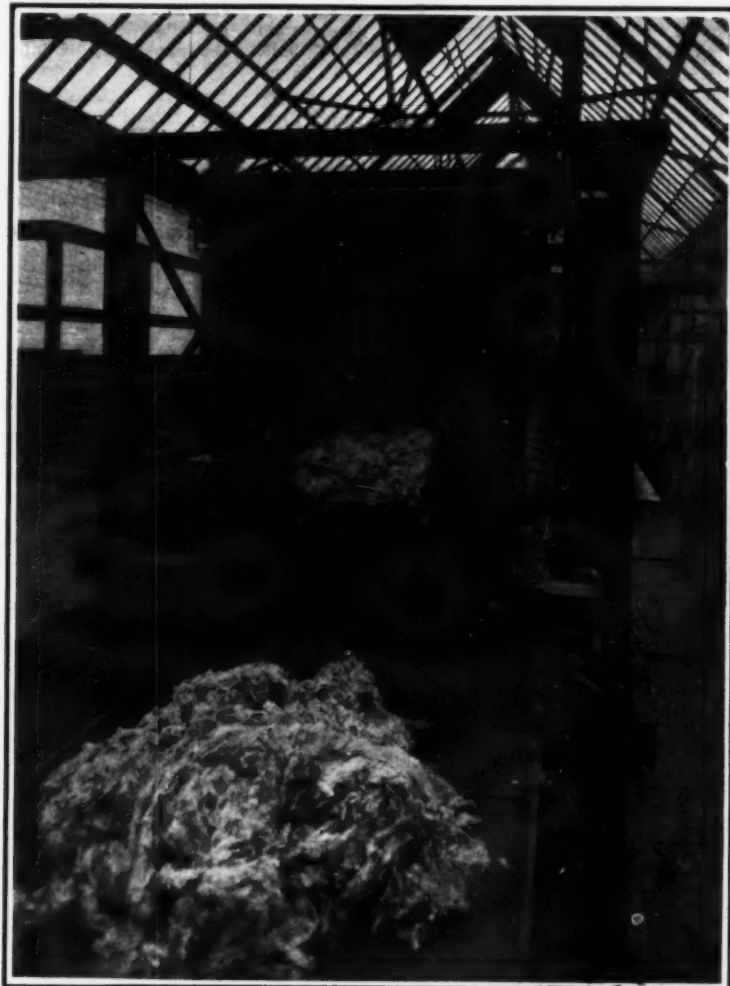
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DELIVERY END OF MACHINE.



FEED END OF MACHINE.



SIDE VIEW FROM DELIVERY END, SHOWING CENTRIFUGAL PUMPS CONNECTED WITH EACH COMPARTMENT.

A NEW CONTINUOUS PROCESS FOR DEGREASING WOOL.

DEGREASING WOOL.

A NEW CONTINUOUS PROCESS.

A new method and a machine for degreasing wool by continuous process have been invented by Frank and Constantine Shuman. An actual plant has been constructed, which is contained in a one-story building about 50 feet by 125 feet.

The entire machine is hermetically sealed, thus preventing the escape of vapors.

The accompanying diagrams showing the longitudinal section and cross section of the machine are taken from the patent drawings; hence they clearly show the complete process, but are not as elaborate as working drawings. The machine as actually built has many more compartments, and contains many valuable features not indicated in these engravings.

The machine, which is about 50 feet long, has nineteen compartments, 10, 11, 12, 13, 15, 16, and 17, each one being 18 inches high. The space above these compartments is all open to allow for the passage of the wool. Each of these compartments has connected to it at the bottom a centrifugal pump, 22, of a capacity of 100 gallons a minute, with a distributing pan, 19, placed above the wool; in each compartment the pan is so arranged that any portion or all of the liquid that is pumped up and distributed over the wool can be returned either to its own compartment or to the compartment immediately preceding it.

The wool, carried between endless aprons, 4 and 5, of metal, enters the machine through a sleeve, 7, forming a seal. The solvent does not vaporize to any extent, and should it do so, the wool entering the sleeve absorbs any vapors that may be formed. The aprons conveying the wool pass over suitable rollers and are carried over the solvent, some inches above the partitions forming the various compartments, and then pass in a horizontal position through the entire length of the machine to the last compartment, 17.

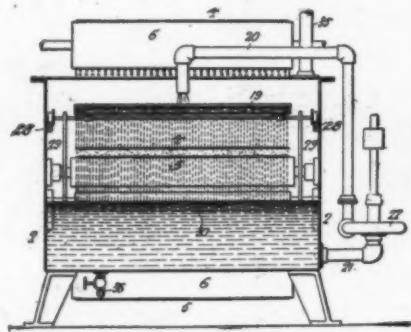
The aprons carrying the wool, as they pass over the various compartments, meet a heavy downpour of the solvent, and the first downpour of solvent is carried back on to the compartment from which it came, by proper mechanism. The purpose of this is twofold: the wool, according to the weight fed into the machine and its quality, will absorb 20 to 30 gallons per minute. This has to be replaced by solvent taken from the next succeeding compartment, with an additional quantity to keep it in proper condition for degreasing the wool. This is not effected by an overflow from one compartment to the preceding one, but by distributing the flow so that it conveys a given amount of solvent that has passed through the wool back direct to the preceding compartment. Thus the solvent in the compartment from which it has been pumped is not contaminated or rendered greasy by solvent that has been carried forward by the wool. If the wool carries forward, say 20 gallons per minute, then 25 gallons per minute is carried back into the preceding compartment, and this extra five gallons runs away by an overflow at the first compartment where the wool enters, for recovery by distillation.

This operation is carried on in a similar manner through ten compartments. At the last compartment, however, the aprons carrying the wool pass between suitable squeeze rolls, 25. This finishes the degreasing process. The next step is the removal of the potash salts and the solvent that the wool still contains, and this is effected in the following manner: After leaving the last-mentioned squeeze rollers, the wool still carried between the aprons is subjected to a downpour of water, which further removes consider-

able solvent, and is again passed through squeeze rolls, 26. It then passes over seven compartments arranged in the same manner as the solvent compartments in regard to pumps, pans, etc. The action of the water in the first three or four compartments is sufficient to remove all the potash salts at a temperature ranging from 110 deg. to 130 deg. F. All the grease and the potash salts having been removed by the time the wool has passed compartment 15, the temperature of the water is gradually raised in the succeeding compartments till it reaches a point suffi-

cient to distill off the remaining solvent, this action being very much accelerated by the downpour of the water.

At compartment No. 17 the aprons conveying the wool pass out of the machine through a sleeve in a manner similar to their entrance into the machine in compartment No. 1, thus enabling a seal to be made and preventing any escape of vapors. The clean water is fed into No. 17 compartment and runs away at No. 13. The solvent in No. 13 and the water readily separate, the solvent flowing over into No. 12, and the water running into a tank to settle for twenty-



CROSS SECTION.

four hours. This water, apparently containing no solvent, if allowed to remain over night in a quiescent state, is found to contain considerable solvent that otherwise would be lost. If it is desired to recover the potash from the water, it can be readily done by evaporation, as it has been found to be thoroughly practicable to have the water running from the machine sufficiently strong in potash salts to register 60 deg. B ϕ .

On leaving the machine, the aprons carrying the wool separate, and permit the wool to drop on to another apron, by means of which the wool is carried into a set of squeeze rolls similar to those of an ordinary scouring machine. The wool is then fed through a regular wool-scouring machine to remove the soil that still remains.

The method of subsequent handling is to run the wool through a four-bowl set of scourers, the first bowl containing clean water; the second, 10 pounds alkali to 2,000 gallons water; the third, 1 pound soap to 2,000 gallons water; the fourth, clear water; the temperature of all bowls being about 90 deg. F. The small amount of alkali and soap merely softens the water.

The greasy solvent that flows from the machine (and this depends entirely upon the amount fed in) is carried to settling tanks, where it remains for forty-eight hours for the soil to settle. It is then pumped into an ordinary still, the solvent distilled off, condensed, and run into storage tanks, and the grease run into a tank and subsequently barreled.

As the solvent in all its use and circulation is carried in air-tight vessels and pipes, and the wool is introduced and delivered through "seals," there is no fire risk of serious consequence, as was expressed by a well-known insurance man in the remark that "a bonfire could actually be built in the plant without danger of explosion."

A plant with a capacity of 3,000 pounds per hour,

once in three and one-half weeks; while the annual cost (for eight years) for clothing on their double worsted cards with lick-in attachment has been \$24 each. The "strippings" from the cards in working 2,058,000 pounds of greasy wool were 32/100 of 1 per cent, of which the actual fiber was 20 per cent, or 64/1,000 of 1 per cent the wool carded; "fly" was 22/100 of 1 per cent, of which the wool fiber was 40 per cent, or 88/1,000 of 1 per cent the wool carded; and the total wool in the "strippings" and "fly" was thus 38/250, or 1/7 of 1 per cent. Comparison with results from cards using wool scoured in the ordinary way, will show how much more fiber from wool thus degreased goes forward into card balls. The lofty condition of the wool is wonderful, and the production of a card may readily be increased 30 to 40 per cent. The percentage of nolls is decreased by 2 1/2 to 4 per cent, and the production of the combs very considerably increased.

Every calculation made, covering a period of ten years, shows that after the scouring the saving amounts to over 1 per cent per pound on the greasy wool treated.

The water from all these operations may run into any stream without danger of pollution, as it practically carries nothing but soil.

NEW ALLOYS OF ALUMINIUM.

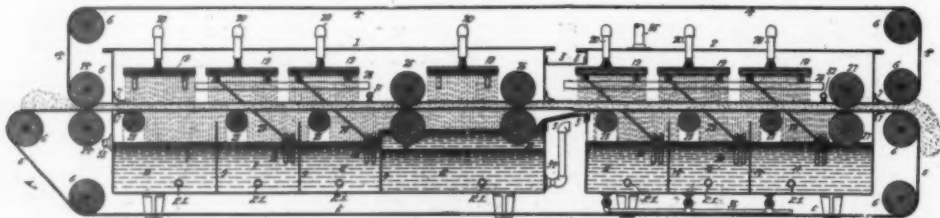
Two new alloys of aluminium are now prepared in Germany on a commercial scale. The first of these has six metals, antimony, aluminium, copper, tin, lead, and zinc. The copper is first melted, then the other metals are successively added. When placing each metal in the mixture, this latter must be stirred thoroughly by means of an iron rod, allowing the fire to slacken by degrees. At the end of the operation a wood piece must be used instead of the iron rod for the stirring, as this is found to give a more homogeneous mixture and otherwise improves the alloy. The proportion of metals which gives the best alloy is the following: copper, 1.20 per cent; tin, 12 per cent; lead, 0.80; antimony, 14; aluminium, 35; zinc 37 per cent. Such alloy is best adapted for the construction of bearings, as it reduces the friction. Moreover it has a texture which gives it a greater resistance than the bronzes which are generally employed for this purpose, provided it is not worked to an excessive degree.

The second alloy of aluminium is manufactured at the Krupp works of Essen according to the Gosmann patents. It contains 87 per cent aluminium, 8 per cent copper, 5 per cent tin. It is more easily melted, it is claimed, than aluminium-zinc alloys, and it is better worked in the machine. Such alloy is homogeneous and has a relatively high mechanical strength. In this connection we may mention another alloy which does not contain aluminium. It is also suitable for bearings. Four metals are used, German silver, zinc, tin, and antimony. The former is melted in the crucible, keeping the heat exact, and we add successively the zinc, antimony, and tin, stirring well at each addition with an iron rod and then with a wood pole. German silver 50 per cent, zinc 40, antimony 5, and tin 5 per cent are used, but this can be varied. One of these alloys gives a good anti-friction metal and it is claimed that it heats less than other such metals, giving besides a small amount of wear. It is much harder than ordinary bronze.

A CORRECTION.

In the SCIENTIFIC AMERICAN SUPPLEMENT of May 24, 1908, appeared an article entitled "Regarding Armor and Its Attack," purporting to have been written by J. B. Van Brussel. We are informed by Brevet Major W. E. Edwards of the Royal Artillery, that the text of the article is almost a word for word transcript from a paper which he read before the engineering section of the British Association on August 24, 1906. We hereby make suitable acknowledgment to Major Edwards.

It is stated that a patent automatic stop has been experimentally tried with success on the Lancashire and Yorkshire Railway. It can be so arranged that it will shut off steam and apply the vacuum brake without any assistance from either the driver or fireman. The automatic stop is worked by the signalman, or by means of an inclined plane which is fixed between the rails. So long as the signal remains at danger the inclined plane is raised so as to come in contact with a simple arrangement fixed underneath the engine, which acts on the steam-regulator, closes it at once, and applies the brakes throughout the train.



LONGITUDINAL SECTION.

A NEW CONTINUOUS PROCESS FOR DEGREASING WOOL.

doing readily 100,000 pounds per week, can be built at a cost of about \$15,000 for the machine with all the necessary tanks for naphtha and the recovery of the degreas and the stills; a smaller plant will cost less, but not proportionately.

It is in the subsequent operations that the great advantages of this system of wool cleaning will appear. For a period of several years (while using their old "hydraulic" system of naphtha scouring), the cards of a company which is now using this machine have been cleaned and stripped on the average

able solvent, and is again passed through squeeze rolls, 26. It then passes over seven compartments arranged in the same manner as the solvent compartments in regard to pumps, pans, etc. The action of the water in the first three or four compartments is sufficient to remove all the potash salts at a temperature ranging from 110 deg. to 130 deg. F. All the grease and the potash salts having been removed by the time the wool has passed compartment 15, the temperature of the water is gradually raised in the succeeding compartments till it reaches a point suffi-

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WIRE NAIL FALLACIES.

HINTS FOR USERS AND MANUFACTURERS.

BY DR. ROBERT GRIMSHAW.

HAVING been brought more or less into contact and correspondence with wire-nail manufacturers in Europe, I have run across one or two notions which seem to me fallacious, and it might be well to ventilate them.

The first is that American nail machines are more wasteful of power than the German.

They do use more power, for the simple reason that they make more nails; and in a nail machine of any make (even in the crude German ones that work on one end only and have a big wooden slat as a spring to effect or aid the return stroke) the principal consumption of power is for cutting off the wire and striking up the head; not to make the machine itself run, empty.

An Alexander machine (No. 3, for example) running on round wire 3.5 millimeters thick, and cutting off nails 75 millimeters long, uses up about 4½ horse-power. A German machine, on the same work, takes only 2 horse-power. But the American machine turns out 225 nails per minute as a minimum, and the German only 80 as a maximum. Leaving the maximum and minimum out of the question (as not available in ratios) we have $225 : 80 :: 4.75 : 1.69$, which is all that the German machine should use, at the same rate; whereas it really uses 2 horse-power. Similarly, it is true that on the small sizes the American machine takes 1.75 horse-power and the German only 0.375; but the American makes 700 nails minimum, while the German makes only 160 maximum; and we have $700 : 160 :: 1.75 : 0.38$, which is where the two machines would be about equal if it were not for the maximum and minimum; which in the case of the Yankee "wire biter" allows a loss of one-third the time for the sharpening and other delays, while the German machines have to submit to a reduction for the same causes.

The foregoing is for wire-nail makers. Now for something that is intended both for them and for a far more numerous class, the wire-nail users. There are plenty of nail makers who demand an extra price for their product, because it is barbed or roughened at or toward the butt end—say about an inch in length, counting from the head, on a 2-inch or a 2½-inch nail. They claim that the barbed and even the roughened nails hold better; and many customers believe this.

In one sense both the makers and the users are right. If a barbed or a roughened nail is driven into a block, it will require more force to pull it out than a smooth one of the same diameter driven under similar conditions into the same block.

But nails are not usually employed for the purpose of weighting wood blocks. The most usual purpose is holding two boards together, or a board to a beam; that is, in most cases they pass through one piece and partly through another, and their purpose is to keep the two pieces from coming apart. We will leave clinching out of the question and consider two slats, A, B, of equal thickness, fastened together by a nail which passes through both, as in Fig. 1. We will suppose an unroughened nail, and undertake to separate the two slats by prying them apart. Naturally, if the pull is at right, the slats will be separated without bending the nail, and the latter will remain in slat A, for the simple reason that the head offers a resistance to the shaft being drawn from A, and the point, as such, makes none to the drawing from B. The shaft being cylindrical, the frictional resistance should be the same in both slats. If it were taper, there would be a greater frictional area in A than in B, and more compression, which in most woods would still further increase the friction in A as against that in B; and with a headless taper nail we know that when the slats came apart, the nail would remain in A, although perhaps a trifle pulled through.

We will now suppose the upper half of the length of the nail to be roughened, and the nail driven as before, but in a fresh place, and the slats separated in the same way. The roughening slightly increases the work of driving during the last half of the distance, and in some woods materially increases the difficulty of drawing from A; so that if the nail were headless, it would in the drawing apart be rather less drawn in below the level of A.

Barbing the upper half of the length of the nail slightly increases the difficulty of driving during the latter half of the distance, and to only an equal extent would prevent the nail, if headless, being drawn through A in the separation process. It would, very much more than roughing along the same length,

prevent the nail being drawn out by the head; and in this particular would in most cases (as in nailing box lids) be a decided disadvantage.

In other words, the roughened and the barbed nail are alike in principle, although not in degree—in the case of a nail which gets equal resistance from each of the two nailed-together members—in that they not only increase the work of driving, but give more work and bother in intentional drawing.

We will now suppose a thin piece, A, nailed to a thick one, B, as in Fig. 2, the nail having a head but no taper, and try the same separating process.

With a smooth cylindrical nail we now have, independent of the head resistance, twice as much friction between the nail and B as between the nail and A; and if it were not for the head, the separation would find the nail in B instead of (as before) in A. If the head is broad enough, however, its resistance to being pulled through A is greater than the extra resistance to being pulled through B, and the nail remains in A.

A headless, smooth cylindrical nail would pull out of A and remain in B.

A headless, smooth, tapering nail might pull through A, or again it might pull through B, according to the taper and the amount of friction.

Roughening the nail for the same length as before (i. e., equal to the thickness of A) we get for Fig. 2:

1. Increased resistance during the last third of the distance in driving.
2. Increased resistance to pulling through A, in



Fig. 1.

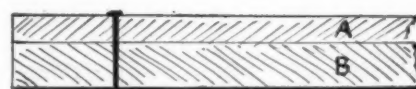


Fig. 2.

separating the slats (this last whether the nail is taper or cylindrical, and has a small head or a large one, or no head at all).

Barbing the nail during the same distance has the same effects as roughing it, but in greater degree.

Roughing the nail its entire length gives with Fig. 1:

1. Increased resistance during the entire distance, in driving.
2. Increased resistance in separating the slats; the roughness in the lower end, however, exactly counteracting that in the upper, so that by reason of the head, the nail would remain in A, as with a smooth nail.

Roughing full length with Fig. 2 we have:

1. Increased resistance during the entire process or operation of driving.
2. Increased resistance in separating the slats; the roughness in the lower end, however, lessening the overbalancing effect of the head.

Barbing full length with Fig. 1, we get:

1. Increased resistance during the entire operation of driving.
2. Slightly increased resistance to drawing through A.

3. Very much more than this amount of resistance to drawing through B, so that with a small head the nail might remain in B; with a large one, however, it remains in A.

Barbing full length with Fig. 2, we have:

1. Increased resistance during the entire driving operation.
2. Slightly increased resistance to drawing through A.

3. Very much more than double as much frictional resistance to pulling out of B as to pulling through A; so that it would take a larger head than in Fig. 1 to make the nail remain in A.

We thus come to the conclusion that except for nails with insignificant heads, either roughing or barbing that part of the nail which is next the head, and which remains in the upper one of the two or more pieces nailed together, is worse than useless, particularly for box lids.

If we rough or barb only the lower half or the lower third of the nail (i. e., that part next the point) we

get, it is true, a slight extra resistance in driving, as where the roughness or the barbs are at the butt end; but the holding effect—particularly with barbs—is materially increased, being in fact partly equivalent to clinching, with the additional advantage that it can be effected where clinching would be unsightly, or where there is no room in which to clinch.

But all those manufacturers who roughen or barb the upper part of the nail (next the head) are in nineteen cases in twenty putting the cart before the horse.

I now want to get back to the manufacturing end of it. Occasionally a wire-nail manufacturer comes along and demands that his nail machine shall roughen the nail as well as make it.

This is unreasonable and unpractical, in connection with any kind of a wire-nail machine.

There is such a thing as overdoing universality, automaticity, etc., especially in machines, which work from continuously-fed material, as wire coils, paper rolls, etc.; and yet it is exactly these which seem to be most handicapped by unreasonable demands.

It is not too much to demand of a floor-board planing and matching machine that it shall work all four surfaces at once; i. e., plane the two sides and put feather and groove, respectively, on the two edges; because these finished faces must have a certain relation to each other, and the time lost in adjusting matcher heads is not nearly so great as that which would be demanded to run the stuff through a second machine. It would, however, be unreasonable and unpractical to try to make the planer and matcher paint the boards, or print advertisements, or mark their length, thereon. The two sets of functions are entirely different.

So with the nail machine. It is so much more easy to have the roughing or barbing done by the mill on the coils, either directly at the time of drawing or at a separate operation, that it would be folly to have the nail machine liable to be thrown out of work by the failure of some trifling corrugated roller or the heating of some extraneous bearing.

The great 4,000-barrel per day flour mills in Minneapolis are arranged in sections, so that the clogging of a conveyor or the specking of the flour from one reel cannot put the entire mill out of business, nor affect the entire product. Although the operations of breaking, separating, grinding, bolting, etc., are of necessity consecutive, the making of the mill in sections, each complete in itself, not only enables running on part capacity, but permits stoppages and lessened expense.

Those who remember the late Emil Loiseau's experiments in Philadelphia with the manufacture of egg-shaped lumps of artificial fuel from anthracite slack and rye-flour, will call to mind that one of the principal claims for his process was that it was continuous or consecutive and automatic. The stuff was measured, mixed, compressed, varnished, and dried, "all without labor"; and the expensive model was considered "a triumph of human ingenuity." Yet it was precisely this feature of dependence that made the whole process, when installed in Port Richmond on a working scale, a complete failure.

If nail-machine makers were to comply with the request that their machines rough or barb the wire then consumers would call for a galvanizing or a wire-drawing attachment. The principle is the same; only the degree is different.

In the rebuilding of the Quebec Bridge, it is said that the engineers who have been retained by the Dominion government will consider the advisability of providing for at least 10 feet more headroom from the water than existed under the former structure. It may be remembered that the height of the old Quebec Bridge was 150 feet above high water, and that the Montreal Board of Trade feared that this would prevent the large ships of the future from passing up the river to Montreal. The height advocated by the Montreal Board of Trade was 190 feet, which, however, can only be obtained at a cost which is regarded as prohibitory. The tallest masts now arriving in Montreal are those of the Allan liner "Virginian," which are of a height of 141 feet. Under the old Quebec Bridge these would have passed with 9 feet to spare. But the masts of the "Empress of Britain" and the "Empress of Ireland," of the Canadian Pacific line, are 154 feet high, and for these it would have been necessary to await the ebb of the tide if they wished to pass under.

WIRELESS TELEPHONY.—II.

ITS HISTORY AND PRESENT STATUS.

BY REGINALD FESSENDEN.

Continued from Supplement No. 1732, page 174

2. *Transmitters.*—The types of transmitters most commonly used are the carbon transmitter and static transmitter, and the carbon transmitter relay.

Fig. 12 shows the standard type of carbon transmitter.

It was found that the ordinary carbon transmitter was unsuited for wireless telephonic work on account

* Copyright, 1908, by the American Institute of Electrical Engineers, and republished from its Transactions.

of its inability to handle large amounts of power. A new type of transmitter was therefore designed which the writer has called the "trough" transmitter. It consists of a soapstone annulus to which are clamped two plates with platinum iridium electrodes. Through a hole in the center of one plate passes a rod, attached at one end to a diaphragm and at the other to a platinum iridium spade. The two outside electrodes are water-jacketed.

This transmitter requires no adjusting. All that is necessary is to place a teaspoonful of carbon granules in the central space. It is able to carry as much as 15 amperes continuously without the articulation falling off appreciably. It has the advantage that it never packs. The reason for this appears to be that when the carbon on one side heats and expands the electrode is pushed over against the carbon on the other side. These transmitters have handled amounts of energy up to one-half horse-power, and under these circumstances give remarkably clear and perfect articulation and may be left in circuit for hours at a time. Fig. 13 shows a modified form with split back.

Fig. 14 shows a type of condenser transmitter in which the vibration of the diaphragm alters the electrical capacity of the transmitter, thus throwing the circuit in and out of tune or spilling more or less energy through a leakage circuit.

Fig. 15 shows a transmitting relay for strong currents. The only thing noticeable about this is that the telephone magnet is a differential one.

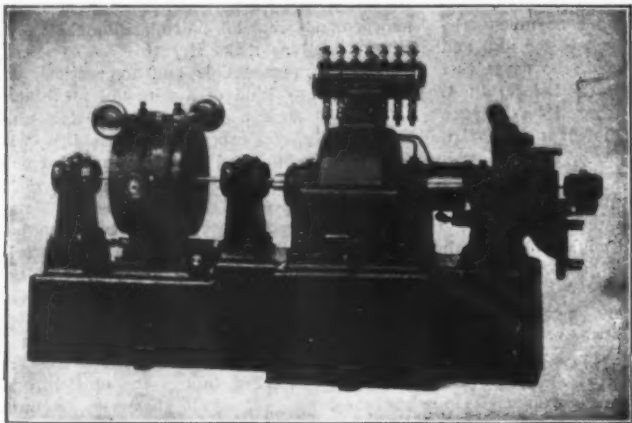


FIG. 11.

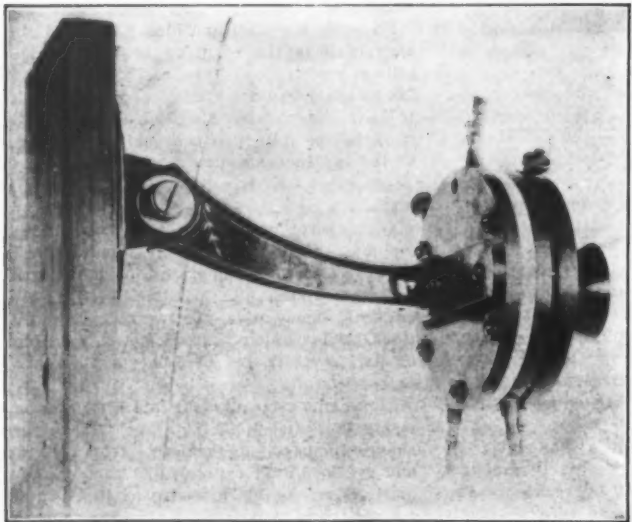


FIG. 12.—ORDINARY CARBON TRANSMITTER.

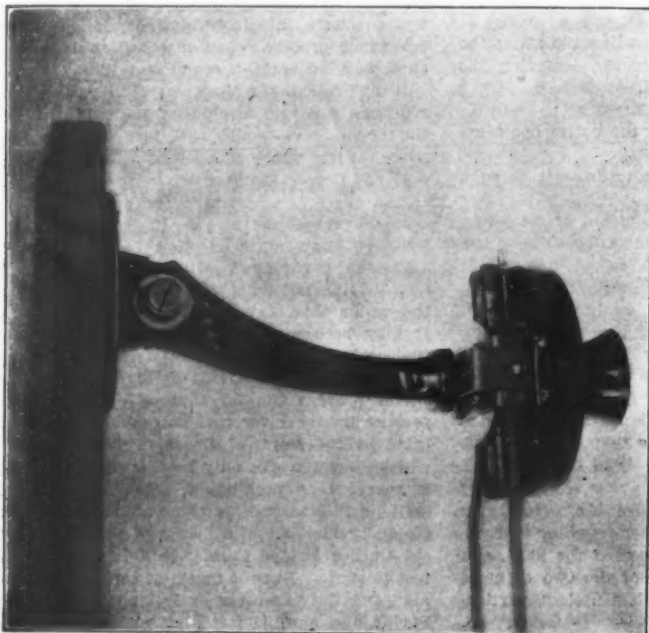


FIG. 13.—TRANSMITTER WITH SPLIT BACK.

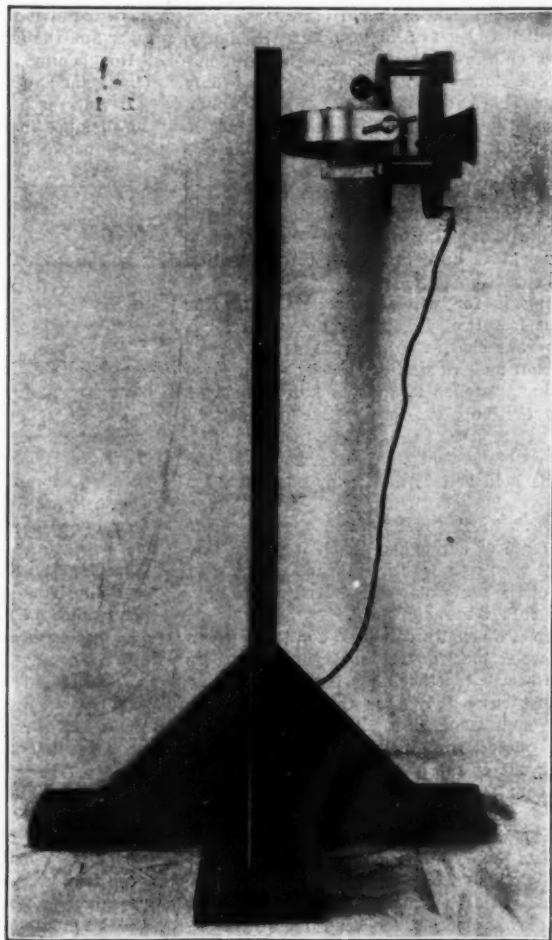


FIG. 14.—CONDENSER TRANSMITTER.

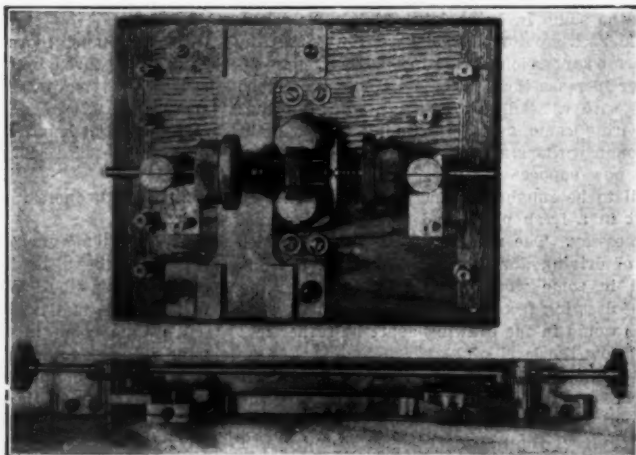


FIG. 15.—TRANSMITTING RELAY FOR STRONG CURRENTS.

MARCH
Fig. 16
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off New Yo
New York,
New York

Fig. 16 shows another type of transmitting relay, for amplifying very feeble currents. It will readily be understood that where a person in Albany, for example, wishes to talk to another person on board a ship off New York, the wireless station being located near New York, the volume of transmission received at New York will not be very strong, and while it may

be possible to transmit it without amplification, amplification is advisable.

This receiver is a combination of the differential magnetic relay and the trough transmitter. An amplification of fifteen times can be obtained without loss of distinctness. The side electrodes of the trough are water-jacketed. The successful amplification de-

pends upon the use of strong forces and upon keeping the moment of inertia of the moving parts as small as possible. Amplification may also be obtained by mechanical means but as a rule this method introduces scratching noises which are very objectionable even though comparatively faint.

Other types of transmitters have also been used,

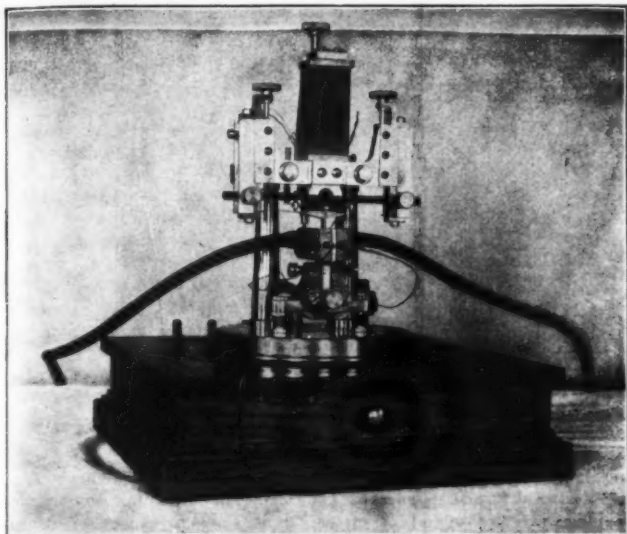


FIG. 16.—TRANSMITTING RELAY FOR AMPLIFYING FEEBLE CURRENTS.

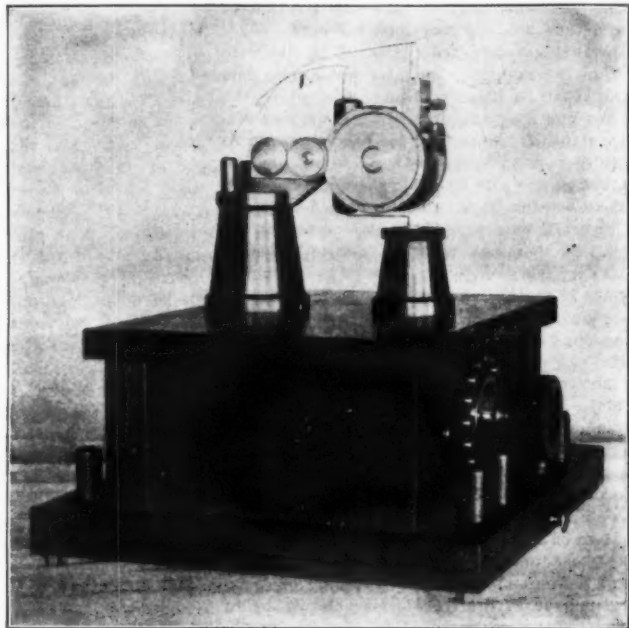


FIG. 22.—LIQUID BARRETTTER.

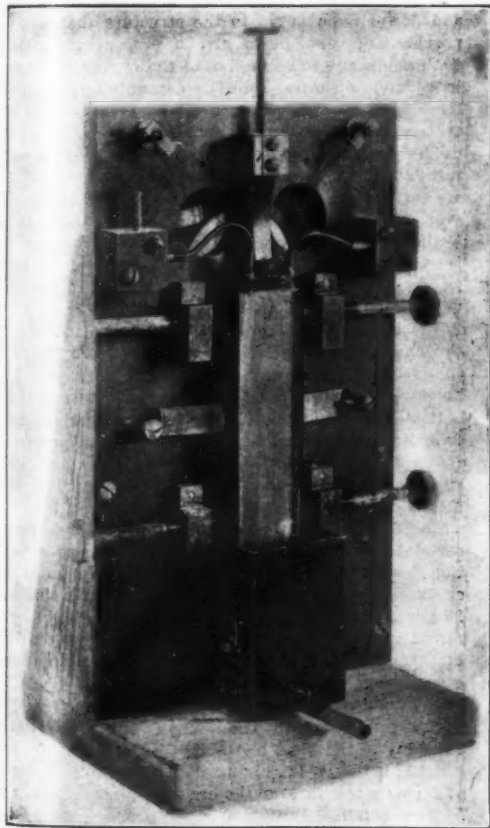


FIG. 17.—LIQUID JET TRANSMITTER.

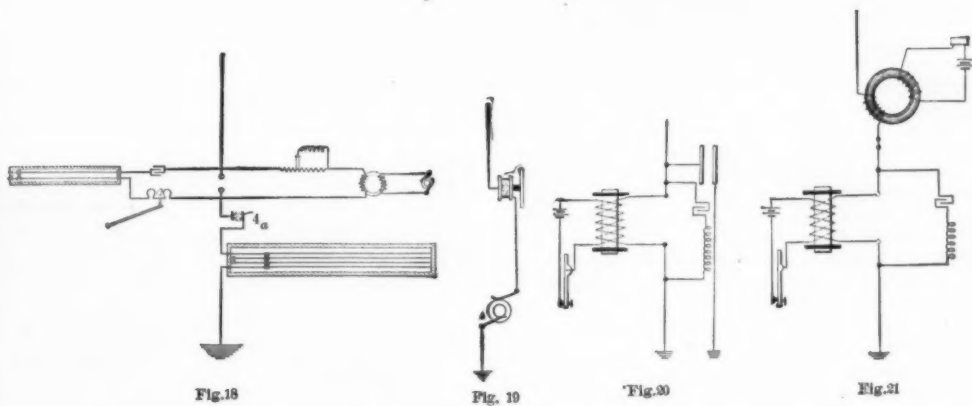


FIG. 18.—TYPE OF ARC CIRCUIT. FIG. 19.—CONNECTION FOR HIGH-FREQUENCY ALTERNATOR. FIG. 20.—CONDENSER-TRANSMITTER CIRCUIT. FIG. 21.—MODULATION ACCOMPANIED BY CHANGING THE INDUCTANCE OF ONE OF THE OSCILLATING CIRCUITS.

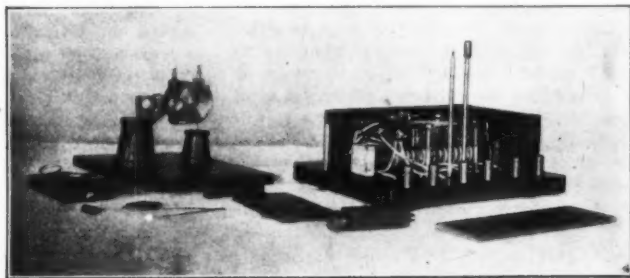


FIG. 23.—THE LIQUID BARRETTTER.

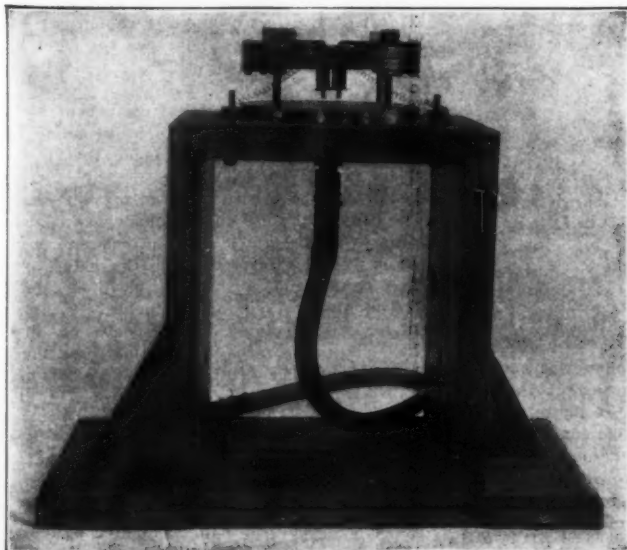
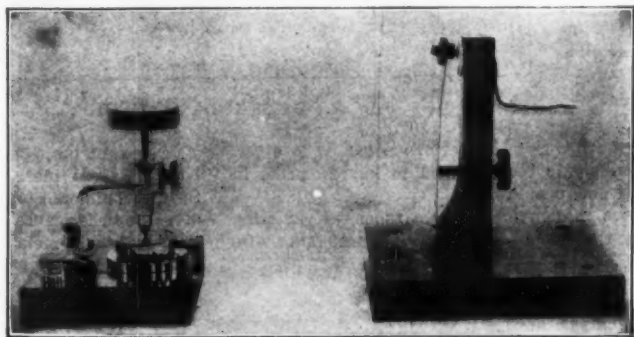


FIG. 17A.—LOUD-SPEAKING TELEPHONE RECEIVER.



Figs. 25 AND 24.—VACUUM TUBE RECEIVERS.

such as liquid jet transmitters, Fig. 17, transmitters operating by closing the air-gap in a magnetic circuit, and so changing the inductance of the oscillating circuit, etc.

Fig. 17A shows a loud-speaking telephone receiver. A small iron disk is placed opposite a nozzle through which air at high pressure is blown. As is well known, this causes the disk to be held close to the nozzle. The telephone magnets alter the position of the disk and thus produce very loud talking.

The transmitting relays are connected in the wire line circuit in the same way as the regular telephone relay, except that in place of being inserted in the middle of the line they are placed in the wireless station and an artificial line is used for balancing. There is no difficulty met with on the wireless side of the apparatus, but on the wire line side there are the well-known difficulties due to unbalancing which have not yet been entirely overcome. For the correction of these difficulties, therefore, we must look to the engineers of the wire telephone companies. At present the difficulties are if anything less than those met with in relaying on wire lines alone.

3. *Transmitting Circuits.*—Fig. 18* shows a type of arc circuit.

Fig. 19† shows a suitable type of connection for use with a high-frequency alternator.

Fig. 20‡ shows a type of circuit for use with the condenser transmitter.

Fig. 21§ shows a type of circuit in which the modulation is accompanied by changing the inductance of one of the oscillating circuits.

As a matter of fact the transmitter may be placed almost anywhere in the circuit between the arc or dynamo and the antenna, or between the arc or dynamo and ground, or in the transformer circuit, or in shunt to an inductance or capacity, the results obtained in all cases being indistinguishable. The sole criterion of success seems to be that the transmitter should be capable of handling the energy and the circuit should be properly adjusted. Some success has also been attained by placing the transmitter in the field of the dynamo, but this method requires very careful designing of the field circuit.

4. *Receivers.*—The receiver which the writer has found most satisfactory for general purposes is the liquid barretter. Figs. 22 and 23 show this receiver. It consists of a fine platinum wire, about a ten thousandth of an inch in diameter, immersed in nitric acid. Tests made with this receiver show that it responds without apparent loss of efficiency to notes as high as 5,000 per second. Some very careful measurements recently made by my assistants, Messrs. Glaubitz and Stein, give the following results:

Voltage of high frequency circuit necessary to produce readable signals	15×10^{-5} volts.
Ohmic resistance of receiver	2,500 ohms.
Value of high frequency current necessary to produce readable signals	6×10^{-8} amperes.
Electromagnetic wave energy required to produce audible note for period of one second	1×10^{-4} ergs.

The telephone used for detecting the signals had a resistance of approximately 1,000 ohms. Some measurements were made to determine the change of current in the telephone circuit by using a sensitive galvanometer in series with the telephone but the results obtained were obviously too low, possibly on account of the electrostatic capacity of the turns of the galvanometer with respect to each other. It will be noted that the amount of electromagnetic wave energy necessary to produce a signal is considerably

in series with a hot-wire ammeter, to determine the voltage necessary, and by introducing resistance in series with the barretter to determine the resistance of the barretter. The figures were also checked in a number of other ways and very concordant results were obtained, so that it is believed they may be relied upon.

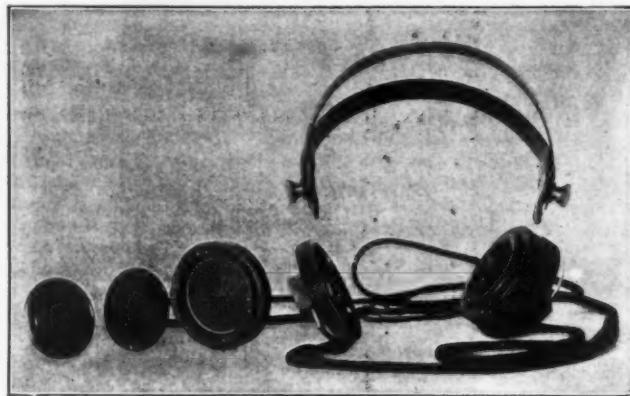


FIG. 28.—HETERODYNE RECEIVER.

The previously mentioned thermo-electric receivers or rectifiers of Dr. Austin and Mr. Pickard shown in Figs. 24 and 25 and the vacuum tube receivers of Fleming, De Forest, and Cooper Hewitt also act very satisfactorily. The fact that the writer has not been able to get as good results from them may be due to greater familiarity with the liquid barretter and heterodyne receiver.

Figs. 26, 27, and 28 show a form of heterodyne receiver adapted for use for telephonic work.

(To be concluded.)

SAFETY FACTORS IN DAMS.*

THE safety factor of a dam is simply an expression denoting its ratio of strength as compared to the pressure of water it has to sustain, and should be large

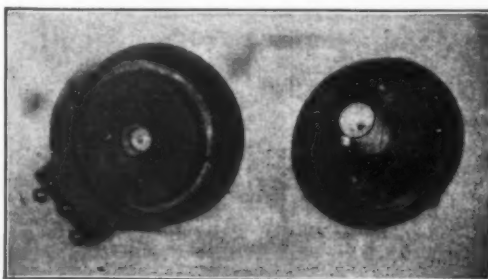


FIG. 36.—HETERODYNE RECEIVER.

enough to compare favorably with current practice in other branches of engineering, such as bridges, buildings, machines, gears, cables, ropes, etc.

Old Spanish dams, as represented by the Val de Inferno, Alamanza, Alameda, etc., had good safety factors, and had also the advantage of being curved or polygonal on plan, and had also a good width on top to act as an aid in preserving the alignment, and to help take up unequal loading. In the year 1838 a method of ascertaining the pressures in a stone wall was developed in France, and at a later date a typical section of dam called the scientific profile section

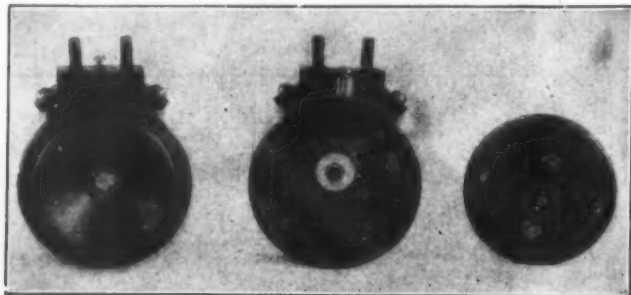


FIG. 27.—HETERODYNE RECEIVER.

less than that given in a previous note.† The difference is possibly to be attributed to improvements in adjustment and operation.

The above measurements were taken by shunting the barretter across a piece of straight resistance wire

* U. S. patents Nos. 706,742, June 6, 1902, and 730,752, April 9, 1903.

† U. S. patent No. 706,742, June 6, 1902.

‡ U. S. patent No. 706,747, September 28, 1901.

§ U. S. patent No. 706,747, September 28, 1901.

¶ U. S. patent No. 706,640, March 30, 1902.

¶ Electrical World and Engineer, October 31, 1905.

* Extracts from remarks made by Mr. John S. Fielding, in opening a discussion at a recent meeting of the Toronto Engineers' Club. Republished from Canadian Engineering.

The scientific profile section has had sway since that time, but the safety factors have been deteriorating until we have such dams as Bear Valley, or Sweet water, with factors of safety against sliding (S.S.F.) of less than unity, reliance for remaining in place being in the curved plan delivering part of the load to the banks.

Drawings of a great many well-known dams of European, American, and Canadian construction and a table of their dimensions, pressures, weight, and safety factors show that the reverse of improvement is taking place, and there is no valid relationship between using the scientific method of finding the pressure and after having found them to adopt an upstream and downstream curve to the structure that will not provide area enough to give a proper safety factor against sliding. The finding of the curves of pressure is a simple operation, but the determining of the outline of the structure is done in two ways by men who are quoted as authorities, one method being by the use of the calculus, and the other being by guess or rule of thumb, and both apparently give results that are satisfactory to the users. These calculations, however, are all to the end of determining the stability against overturning, which in modern structures has been arranged to give a safety factor of 2 or more, whereas the safety factor against sliding in the same design would be 1.3 to 1.5.

The sliding out of place is more to be feared than the overturning, and if the structure were strong in this regard, having say S.S.F. of 2.5, there would be no need of computing the overturning moment at all. It will be seen that it is not sufficient for engineers to quote that they have secured the lines of pressure—reservoir full or reservoir empty—to come within the middle third of the base, but should first make sure that the structure has a decent S.S.F.

The S.S.F. has to take care of more items of uncertainty than is generally realized. A pure assumption has to be made in the first instance as to the coefficient of sliding; this may not be nearer than 25 per cent of the actual, or may vary greatly at different parts of the base; there may be imperfections in the rock with vertical seams giving upward pressure, imperfections in the mass from action of careless workmen, poor material, effect of rain, frost, or sun, also movement at the top sufficient to disturb the adhesion of the base, blows of ice floes, logs, etc., and a S.S.F. of 1.3 or 1.5, giving 30 per cent to 50 per cent of excess strength over the assumed pressure seems to be very small.

Another item that is frequently overlooked is that the pressures increase very rapidly when the water is above crest level, a depth of flood of 2 feet over a 10-foot dam, 4 feet over a 20-foot dam, or 8 feet over a 40-foot dam, giving 1.4 times the crest level pressure, consequently being sufficient to eliminate a S.S.F. of 1.4.

The idea that the vertical component of the water pressure should not be utilized seems to be wrong, since the 62.5 pounds per cubic foot of weight of water is well worth utilizing.

Attempts have been made to prevent erosion below the dam by the use of long sloping aprons; a vertical drop to a hard, thick apron of concrete is preferable so as to take the speed out of the water, by changing its direction and causing it to move off quietly.

The Austin, Columbus, Chamble, etc., are instances of modern structures on this continent, all of which have slid out of place like packing cases along a warehouse floor. The Austin dam being a loss of \$70,000, and tying up a power plant costing a million and a quarter dollars, for the past eight years. Many dams are standing, with a small safety factor, but no one knows how near any of them were to failure, and the best English dam, namely, Vyrnwy Dam of the Liverpool waterworks, has been reported upon on two different occasions since its completion by a Royal Commission, although its strength was theoretically 1.5 times the pressure.

SAN FRANCISCO'S FIRE SERVICE.

A NEW AND EFFICIENT SERVICE.

BY DAVID PAUL.

PLANS for the most comprehensive system of fire protection ever proposed for an American city have been approved by the San Francisco Board of Supervisors, and the work of carrying them out, at an expense estimated at \$5,250,000, has begun.

The area which will be protected, about 5,400 acres, is a third larger than the area embraced in the auxiliary fire protection system of Greater New York. The new mains are planned to be practically proof against earthquakes, and groups of bored wells will furnish a supply of fresh water independent of the city's domestic service. For emergencies a salt-water supply will be made also available. Two steel fireboats will protect the water front, and by means of numerous fireboat connections can also deliver water into the general distributing system.

The means which will be provided for the application of water to a fire will be more efficient than in the case of any other city, and the safeguards with which the system will be surrounded are more numerous than elsewhere. The city will be divided into two fire zones, and each will be supplied through an independent distributing system, which can be connected to operate as one when necessary. A special telephone service for the use of the fire department will be installed.

The system which San Francisco has adopted is the result of more than a year of study and investigation by the engineers, T. W. Ransom and H. C. Connick, under the general direction of City Engineer Woodward. The use of portable steam pumping engines and fire engines will be dispensed with, the water being conveyed under sufficient pressure to make them unnecessary. In this way the system always will be ready for instant use; in fact, in many cases it will be used even before the arrival of the firemen. All the water that the department can use will be available at all parts of the protected districts.

One of the interesting features of the system will be gate valves, with which the mains in each street will be provided, to connect with the nearby mains of the distributing system. These valves will serve a double purpose. They will be so placed that the main in any one block may be cut off from the rest of the system, for the purpose of making repairs or inspection, without seriously affecting the supply to hydrants on other blocks. Also, if as a result of a severe earthquake shock, the mains forming the distribution systems in the districts should be broken, it will be possible by closing only five gates entirely to disconnect these broken mains.

The buildings on the areas of "made" ground are to be afforded the same fire protection as those on more solid ground, but the probability of the entire fire protection system being put out of service by the destruction of the fire mains in those areas will be guarded against by the special arrangement of the pipe and gate system referred to. Each of these areas will be provided with its own distribution system of special pipe, which will ordinarily be fed through one open gate valve of sufficient size to provide the necessary supply for private fire services for all ordinary fires.

With the exception of those on hydrant connections, all gates will be inclosed in brick or reinforced concrete chambers, to facilitate inspection or repairs. To make easy their location in an emergency, they will be similarly situated in all crossings, and the gate chambers will be provided with special manhole frames and distinctive covers.

The gate valves will be of the single-disk or wedge type with inside screw, and those 12 inches or more in diameter will be provided with by-passes. They will be designed with a view to use with salt water, and bronze will be employed wherever corrosion is likely to interfere with their strength or proper operation. All bolts will be of mild steel, the stem of Tobin bronze. The gears, gear bracket, gland, stuffing box, bonnet, disk, by-passes, elbows, and operating nut of all gates will be made of cast iron having a tensile strength of not less than 18,000 pounds per square inch. All valves will be designed for a working pressure of not less than the maximum static head at the location in which they are to be used, and tested to a pressure of at least twice the working pressure, and the gears are to be so proportioned that the gates can be readily operated by one man.

After consideration of the requirements of high pressure, together with the probable effects of earthquake shocks and the fact that salt water may at times be used in the system, the conclusion was reached that

cast iron is the most desirable material for the pipes. In firm ground they are to be of the ball and spigot type, with a specially designed lead joint. There are to be deep double lead grooves in both spigot and hub end of each pipe, so placed that when the pipes are laid they will be opposite to one another. In areas of artificially filled or made ground, a special type of cast-iron pipe and joint will be used. This arrangement will permit of considerable more movement in the pipes than will the ordinary ball and spigot joint.

All mains will be connected where they intersect, in order to obtain as perfect a circulation as possible, and where there are curves in the lines, the sections of pipe will be bolted to the mains in the same manner.

Fireboat connection will be provided along the water front, and connections will be installed in duplicate. To remove sediment from the mains, blow-off valves will be provided at the low points of the distributing system. They will be arranged to discharge directly into the sewer. To prevent the accumulation of air in the pipe lines, automatic air valves will be installed at the high points of the system. Automatic relief valves will be installed at a number of points on the distributing system of each zone, to reduce the dangerous effects of water hammer. These devices will be located in selected fire-engine houses, where they can be inspected and given the necessary care and attention. They will be arranged to discharge into the sewer.

After consideration of the quantities of water which have been used in great fires in this country and in England, and as more than one fire may occur at once, or part of the system may be out of service, it has been decided to provide for the delivery into the distributing system of 43,000 gallons of water for thirteen hours, and 28,000 gallons for sixty-four hours thereafter. This is equivalent to 52,000,000 gallons in the first twenty-four hours, and 40,000,000 gallons per day thereafter, or more than is at present available in San Francisco for all purposes. This quantity of water would be sufficient to cover an ordinary city block more than 60 feet deep in twenty-four hours. Provision is to be made for standing pressures up to 327 pounds per square inch at the hydrants.

There will be two main storage reservoirs, each having a capacity of 5,000,000 gallons, which will hold the water for the supply of the distributing reservoirs. The former will be located on an eminence called Twin Peaks, at an elevation of 755 feet. Two lines of 20-inch pipe will connect these two reservoirs to the distributing system and to the distributing reservoir of the upper zone.

The upper zone will include all those portions of the protected area the elevation of which is more than 150 feet. It will be supplied from a reservoir of 500,000 gallons capacity situated at an elevation of about 490 feet. The lower zone will embrace all those portions less than 150 feet high. It will be supplied from a concrete reservoir of 1,000,000 gallons capacity constructed at an elevation of about 340 feet.

The division into zones is made because the pressure from the storage reservoirs would be greater than would be needed except for the very largest fires, and maintaining that pressure constantly on the fire mains would involve considerable expense and some danger. When necessary, however, either zone may be connected with the Twin Peaks reservoir.

The storage and distributing reservoirs will be supplied with fresh water from groups of bored wells, from which the water will be pumped through the mains of the distributing system by two fresh-water pumping stations. These stations will be identical in design, and the wells from which they will be supplied will be bored at intervals of about seventy feet in the adjacent streets.

Investigations have shown that at least fifty gallons a minute can be drawn from each of a number of 12-inch wells in the selected localities without lowering the water plane more than 100 feet below the surface of the ground. As the pumping capacity of each station is to be 1,050 gallons per minute, the plans provide for the sinking of twenty-one wells in connection with each.

The water from the wells is to be raised to the surface and delivered into a reinforced concrete cistern of 175,000 gallons capacity situated under each pumping station by air pumps of the Pohle air lift type. These pumps will consist of air compressors in each station, a separate air pipe from the stations to each well, and water pipes in the wells and leading therefrom to the cisterns under the stations. The only mov-

ing parts about the whole arrangement subject to wear or requiring attention will be in the air compressors, and these can be easily operated by one man.

The pipes in the wells will contain no valves or moving parts of any kind, and consequently will not be subject to wear or liable to become clogged by the sand, which is pumped in greater or less quantities from nearly all bored wells in the city. It is recognized that pumps of this type are very inefficient in regard to the amount of power necessary for their operation, but their extreme simplicity and low cost of maintaining and their reliability of action far outweigh the objection that the cost of power is comparatively high. The pumps for forcing water from the cisterns into the distributing mains will be of the multi-stage turbine type.

Electric motors will be employed, and to start a unit it will be necessary merely to close the proper switch in a station. The mechanical equipment of each station will be: Two duplex air compressors, each capable of compressing 600 cubic feet of free air per minute to a pressure of 80 pounds per square inch; two 100-horse-power electric motors to drive these compressors; two three-stage turbine pumps, each driven by a 75-horse-power electric motor connected directly to its shaft, the capacity of each being 525 gallons per minute against a head of 330 feet; two five-stage turbine pumps, each driven by a 125-horse-power electric motor, connected directly to its shaft, each pump having a capacity of 525 gallons per minute against a head of 500 feet.

There will also be a five-ton traveling crane, air receivers, all the necessary suction and discharge pipes, fittings and valves, a suitable switchboard, and automatic instruments for recording the performance of the pumps and motors. In addition to the space required for the machinery, provision will be made for the accommodation of a regular fire company.

Two salt-water pumping stations will be constructed near the bay shore, the foundations of both buildings resting directly on the solid rock. Each will be of sufficient size to provide for the installation of machinery to pump 16,000 gallons a minute against a pressure of 300 pounds per square inch, together with the quarters for the men necessary for its operation. Because of the possibility of gas and fresh-water mains and electric power wires being broken and of means of transportation being interrupted, each station will be independent of all outside sources of power, fuel, or supplies for at least forty-eight hours while operating at full capacity. Because of the existence of an old geological fault, and the possibility of any pipes which cross it being broken, the salt water will be obtained from the easterly or bay side of the peninsula.

The plan for the fire telephone system provides for 360 instruments for the exclusive use of the fire department. There will be six call boxes on each circuit, and the circuits will be so arranged that those in areas of made ground can go out of service without affecting any of the other circuits. The call boxes will be provided with connections for portable instruments to be carried by the officers of the department, and will be so located that at least one will be within convenient distance of any part of the protected districts, the distance from any hydrant to the nearest box not exceeding one block. All the telephone wires will be underground.

If the officer in charge at a fire desires the water pressure increased, he will be able to telephone to the gateman at one of the reservoirs, who by operating gates controlled by hydraulic pressure will be able to connect the mains of the lower zone directly with the mains of the upper zone, and so on till the needed pressure is obtained.

It will not be necessary to operate the fresh-water pumping stations during a fire, as the large storage capacity of the reservoirs will insure a sufficient supply at all times. The necessary pumping may be done at any time. To start or stop a pump, all that will need to be done will be to close or open a switch and two gate valves.

The steel fireboats will ordinarily be used for the protection of property in the vicinity of the water front. In the event of a general conflagration, however, they may be used to deliver water from the bay into the distributing system through connections provided on the wharves, or directly into hose lines which may be laid to the scene of the fire. Should portions of the distributing system in the "made" ground along the bay shore be destroyed, they will be of great value in protecting property within those districts.

SUBMARINE EXPERIMENTS OF THE PAST.

SOME MEDIEVAL FANCIES RECENTLY REALIZED.

BY FRANZ M. FELDHAUS.

The history of submarine experiment is more than two thousand years old, but no progress was made for many centuries because so little was known about air, its pressure, its composition, and its function in respiration. Herodotus, in 450 B. C., recorded that the



FIG. 1.—WATER BOOTS.

(From Valturio's "Art of War," printed in 1472.)

Spartan diver Scyllias, who "in the shipwreck off Pelion had saved much treasure for the Persians," appeared in the Greek camp at Artemisium, as a deserter. "It is said that, having plunged into the sea at Appetæ, he never rose until he reached Artemisium, a distance of eighty stadia. . . . If, however, I may give my opinion of this matter, it is that he came to Artemisium in a boat." The story may be true, however, for Aristotle, a hundred years later, mentions devices by the aid of which men could work under water. The description is not clear, but it is evident that something like a diving bell, having the form of an inverted tumbler, is meant, for Aristotle remarks that it is necessary to keep the vessel upright. A simple experiment with a tumbler and a pail of water will demonstrate this necessity and will exhibit another phenomenon which increases the difficulty of working under water. If the tumbler is not held nearly vertical, some of the imprisoned air escapes in bubbles and a corresponding quantity of water



FIG. 2.—FIGHTING UNDER WATER.

(From Valturio's "Art of War.")

enters the glass, and even if the tumbler is kept perfectly vertical some water enters, though no air escapes. Hence it follows that the air imprisoned under the glass is compressed. The quantity of water that enters and the compression (and consequently the pressure) of the air increase with the depth to which the glass is immersed. At a depth of 130 feet the

pressure would be so great that neither the human lungs nor any other substance could resist it.

After the experiments of ancient times comes a long blank in the history of diving apparatus. Yet the ancient experience lived on in popular tradition, for a twelfth-century tale represents the conjurer Morulf as escaping from the wrath of King Solomon, who had set a price on his head, in a boat made of leather caked with pitch, which sank beneath the surface when pursued by Solomon's fleet. The most interesting part of the story is the mention of a tube through which the submerged fugitive drew the air required for respiration during a period of two weeks. Now, the air tube was suggested, as a novel improvement in diving apparatus, by the celebrated astronomer Halley, in 1716.

Most of the manuscripts left by military engineers of the Middle Ages contain chapters on diving apparatus, and the oldest printed technical work, Roberto Valturio's treatise on the art of war, published in 1472, describes and illustrates devices for fighting on and under water.

Two of these illustrations are here reproduced. Fig. 1 shows a pair of double-walled boots, inflated with air, which were designed to prevent the wearer from being entirely submerged. In the background is shown a man wearing such boots and maintaining his balance with the aid of a pole. Fig. 2 shows a warrior, clad in a diving suit of leather, fighting under water with a merman. Fig. 3, from a Viennese manuscript of the fourteenth century, represents a diver wearing a suit of leather and a metal headpiece with



FIG. 3.—A DIVER. (14TH CENTURY MS.)

glass windows. The fishes and quadrupeds are introduced to make plain the distinction between water and land. The same manuscript has a drawing of a swimming jacket for the use of divers (Fig. 4). The rectangular part was to be applied to the back, the oval part to the chest. When inflated by blowing into the leather tube, the jacket would enable the wearer to float, but he would sink when the air was allowed to escape. Thus a skillful diver could vanish from sight of the enemy for a short time. The idea appears to have been that he could rise again by inflating the jacket with his lungs while under water, but this is manifestly impossible. About the year 1500 Leonardo da Vinci invented a very simple apparatus for the use of divers, which is illustrated in Fig. 5. It is merely a tube of bamboo, the upper end of which is supported at the surface of the water by a disk of cork, while the lower end is strapped to the mouth of the diver.

It is often asserted that a submarine or diving boat was known to the Franciscan friar Roger Bacon in the thirteenth century. But Bacon merely says: "It is possible to construct apparatus for walking on water and diving, without any danger. Such devices were made for Alexander the Great." Bacon evidently refers to the boots shown in Fig. 1 and the diving apparatus of glass which was assumed, in the popular medieval romance of King Alexander, to have been employed by the famous monarch. This apparatus is mentioned also in Goethe's "Faust" and in several old German myths.

The manuscript history of the world written by Rudolf von Ems in the year 1250 is illustrated with drawings (Figs. 6, 7, and 8) of Alexander's traditional diving bell or globe, and describes it as a frame of iron covered with oiled oxhide, and lighted by many

air-tight glass windows. The king, desiring to explore the depths of the ocean, was put into the vessel, with a supply of food and drink, and lowered by an iron chain to the depth of 30,000 fathoms, where he saw many monsters "too horrible for description."

A manuscript written in 1460, and Valturio's book, printed in 1472, contain drawings of a submarine boat (Fig. 9) propelled by paddle wheels. A similar vessel is pictured in a history of Alexander the Great which was printed in 1488 (Fig. 10). No connection



FIG. 4.—SWIMMING AND DIVING JACKET. (14TH CENTURY MS.)

has been traced between these early fantastic conceptions and the practical diving apparatus which came into use not long afterward, but the history of technical arts of that period has not yet been fully explored.

The first known attempt to work under water with the aid of artificial contrivances was made in 1535, by Francesco del Marchi, for the purpose of raising the Roman pleasure galleys which were sunk in Lake Nemi in the year 39 A. D. The diving bell used in this attempt (Fig. 11) was invented by Guglielmo di Lorena, and appears to have been similar to the apparatus described by Aristotle. The diver, in Oriental dress, is shown suspended by iron straps passing under his arms and legs, under a small diving bell which covers only the upper part of his body, so that his hands can move freely below its open mouth. He can look out through a glass window, and his weight makes it impossible for the bell to tip and fill with water. In 1538 two Greek divers gave an exhibition of a diving bell on the river Tagus, at Toledo, before the Emperor Charles V and an assemblage of 10,000 spectators. Taisnier, the tutor of the imperial pages, thus describes the exhibition: "They suspended a great kettle by ropes, with its mouth downward, and fastened in the middle of it a beam on which they

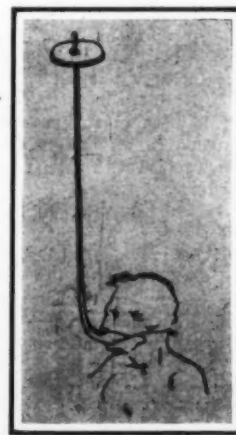


FIG. 5.—A DEVICE INVENTED BY LEONARDO DA VINCI IN 1500.

placed themselves, with a fire. The kettle was then lowered slowly into the water, its equilibrium being maintained by leaden weights attached around its rim. When the kettle was drawn up the men were found quite dry and the fire burning."

Diving bells were successfully employed in 1588 and 1665 in recovering cannon from the sunken Spanish

Armada, and in 1597 by Lorini and in 1778 by Smeaton in construction work under water. Incidentally valuable knowledge was accumulated which subsequently found useful application in the construction of submarine boats.

Wilhelm Bauer's diving boat, of excellent design, failed because it was in advance of its time. Johnson's submarine boat was confiscated by official decree in 1805. The modern history of the submarine began with the appearance of the Swedish inventor Norden-

ive than the expansive force of steam, the vaporous form of the same oxide of hydrogen, or the explosive hurry of certain chemical reactions, its very quiet yet inexorable insistence, culminating when resisted in disastrous effects, is one of its most impressive features. In the determined act of setting themselves in accordance with the well-defined homogeneous structure of one or other of the 32 classes of crystal symmetry, the molecules of a chemical compound are capable of exerting a force which is well nigh incredible, and in the case of water, where the act is accompanied by an expansion of bulk, this power is at its maximum. For, as has already been mentioned, water is one of the few exceptions (molten cast iron and the fused metals bismuth and antimony being almost the only others) to the general rule of contraction on solidification. Moreover, in the case of water, the expansion with cooling begins at 4 deg. C. (or 7 deg. F.) above the freezing point (0 deg. C. or 32 deg. F.), and proceeds steadily until the latter is reached, when, at the very moment of crystallization, it suddenly increases in volume by no less than 10 per cent. This doubly exceptional behavior of water, and particularly the sudden expansive leap, as the molecules marshal themselves into disciplined order to form the lattice structure of the rhombohedral-hexagonal class of symmetry, is of vital consequence to aquatic life. For the lighter ice floats as a protective layer on the surface of the water, and thickens only with comparative slowness, while the heavier layers still at the temperature of 4 deg. C. of the maximum density have no tendency ever to approach the surface in quiet circumstances, so that, even in the most severe winters, the fishes and other marine organisms, fortified by their cold-blooded constitutions to withstand a temperature just above that of freezing water, are preserved from otherwise inevitable destruction. Even in troubled rivers like the St. Lawrence, where the mixing up of the water by its own turbulence brings the temperature of the whole down to 0 deg. C., and facilitates the formation of ground ice in contact with the colder bed of the river, nothing more serious than the annual surface blockade by more or less continuous ice floes, partially consisting of risen ground ice, occurs. This beneficent effect of the exceptional behavior of water is one which cannot fail to impress the mind with its obviously designed character.

Absolute proof of the crystalline structure of ice is afforded by the fact that it exhibits double refraction in every direction but that of the principal axis of the hexagonal prism, which is perpendicular to the freezing surface. The amount is small, but sufficient to cause a small spot on a sheet of white paper to appear double. Again, if a plate of ice also parallel to the plane of freezing is examined in the dark field of the crossed Nicol prisms of a polariscope, using convergent light, an interference figure is observed, consisting of a dark rectangular cross and a series of concentric rainbow-colored rings; this figure is characteristic of the crystals of the hexagonal, trigonal and tetragonal systems, all of which possess a principal axis of symmetry, which is indicated in section by the center of the cross. Moreover, the two indexes of refraction have actually been determined, corresponding to the direction of the principal axis and to directions perpendicular thereto, the values found being 1.3091 and 1.3104. It has thus been definitely established that water crystallizes in the trigonal system, and in the same class of that system, the rhombohedral-hexagonal class, as calcite; the commonly developed forms are the hexagonal prism (which is just as much a form of this trigonal class as of the hexagonal system), the rhombohedral, and the basal plane, which latter closes the prism in the common tabular crystals of ice or snow.

The angles of the first and third forms are fixed by the symmetry, but the rhombohedral angle of 109.5



FIGS. 6 AND 7.—DIVING GLOBES. (FROM A 13TH CENTURY MS.)

The first attempt to navigate a vessel under water was made by the Dutch physicist Cornelius Drebbel, who acquired celebrity by numerous inventions. Having turned his attention to the construction of torpedoes he sought a method of bringing the torpedo, under water and invisible, to the side of the enemy's ship. In 1624 he experimented on the Thames with a submarine boat of his own invention, which is said to have gone under water from Westminster to Greenwich. The vessel was propelled by oars, sunk by admitting water into a tank, and raised by dropping ballast. It was provided with boring tools, working in stuffing boxes in the side of the vessel, by which the enemy's ships could be perforated, and with long poles carrying torpedoes at their ends.

Other experiments were made by Borelli, Fournier, Mersune and other inventors, but the first practical submarine vessel was constructed by Papin, one of the pioneers of the steam engine. This vessel is described in detail in a letter written by Papin to Huygens in 1691. It had an air tube of leather, the upper end of which was supported by a wooden float, and a centrifugal ventilator. In addition to the entrance turret there were other openings, by means of which explosives could be attached to the enemy's ship without admitting water into the submarine boat. This vessel was seriously injured by the breaking of a crane by which it was being lowered to the water. The Landgrave of Cassel supplied Papin with funds for the construction of another vessel, in which Papin made a voyage beneath the surface of the river Fulda in 1692. The experiment was a complete success, but land-locked Hesse had little use for submarine boats.

In the eighteenth century a Swede, named Elfving, was especially active in designing submarine vessels, the plans of which are still in the possession of the Stockholm military club. Soon afterward the American, David Bushnell, made the first attack on a hostile vessel with a submarine, but the enemy's vessel, the British warship "Eagle," sustained little damage. The first prolonged sojourn under water was made by Robert Fulton who, in his submarine boat "Nautilus," remained submerged five hours on August 17th, 1801.

Since that date very many submarine vessels have

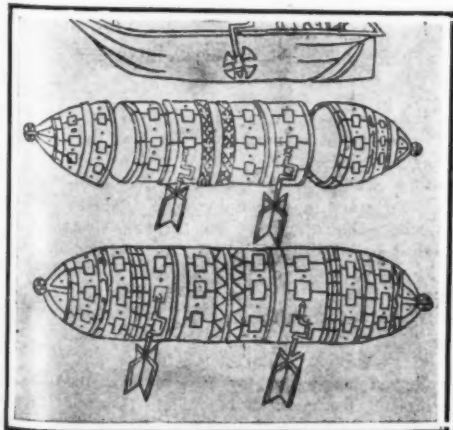


FIG. 9.—SUBMARINE BOAT OPENED AND CLOSED.

been designed, constructed, and tested, and various governments are now building submarine fleets with diligence and secrecy. Yet little actual success in war has been attained by these vessels since the destruction of the "Housatonic," off Charleston, by a torpedo discharged by a submarine boat on February 7th, 1864.



felt in 1882.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Die Gartenlaube.

THE CRYSTALLIZATION OF WATER.

By A. E. H. TUTT, F. R. S.

THE physical facts concerning the solidification of water into ice, such as the amount of expansion which occurs during the act of freezing, the degree of force



FIG. 8.—DIVING GLOBE. (FROM A 13TH CENTURY MS.)

which is engendered when it is attempted to prevent the expansion, the action of pressure in reversing the process and producing liquefaction of ice, and the regelation which occurs on removal of the pressure, have formed the subject of innumerable investigations, and are now well established. But there is one aspect of the formation of ice which is, as a rule, most surprisingly overlooked, and which is in all probability the very essence of the matter—namely, that it is the pro-



FIG. 11.—DIVING BELL (1535).

duction of a crystal or mass of crystals of the solid oxide of hydrogen, H_2O , which is occurring whenever water, the liquid form of that oxide, freezes; and that it is the study of ice as a crystal that can alone yield a comprehensive account of its nature and properties.

The force of crystallization is one of the most powerful of all the physical forces of nature. Less obtrus-



FIG. 10.—KING ALEXANDER'S DIVING APPARATUS. (FROM A 15TH CENTURY PRINT.)

deg. is specifically characteristic of ice. For we now definitely know that the crystallographic angles which are not fixed by the symmetry of any particular substance of definite chemical composition, are the peculiar property of that substance, and different from those of all others.—London Times Engineering Supplement.

THE UNTILLED FIELD OF CHEMISTRY.

THOUGHTS ON THE POTENTIAL ENERGY OF MATTER.

BY ARTHUR D. LITTLE,

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THE volume of chemical literature has become so great, so many compounds have been described and classified, so many methods have been laid down, so much of detail confronts the student, and his field of study has been so sub-divided as to suggest and foster the delusion that the total sum of chemical knowledge must be vast indeed. Vast in its detail perhaps it is, but lacking in those fundamental unities which out of the confusion of detail bring wisdom. Chemistry still awaits its Newton. It still justifies the estimate of Kant, who said of it more than one hundred years ago:

"Chemistry is a science, but not a science in the highest sense of that word; that is a knowledge of nature reduced to mathematical mechanics."

Despite the immense amount of dry detail which we have accumulated and in some measure correlated, chemistry is still in the imaginative era where generalizations are more the result of happy inspiration than of close mathematical analysis.

Chemistry concerns itself with the changes which matter undergoes in its varying relations to certain forms of energy and yet we do not know what matter is nor have we any conception of the real nature of energy. One has only to state in their ultimate terms the problems confronting us to bring a realization of how very far from their solution we still stand. They are, for instance, thus summarized by Karl Pearson:

What is it that moves?

Why does it move?

How does it move?

Where, yet, I ask you is their answer to be found in chemistry?

We have built our science upon the assumption that matter, whatever that may be, is composed of indivisible atoms, of a comfortable and ultimate simplicity, only to find that the atom is in fact divisible and that its structure is undoubtedly complex beyond imagination. As to those phases of energy which are concerned with chemical change, even so great a philosophical chemist as Ostwald says: "Chemical energy is to us the least known of all the various forms, as we can measure neither it nor any of its factors directly. The only means of obtaining information regarding it is to transform it into another species of energy."

So we have gone on for a hundred and fifty years transforming chemical energy into electrical energy or into heat, making minutely refined measurements of the relatively small amounts of energy appearing in our processes, while wholly unconscious all this time of the stupendous stores of potential energy which we now vaguely begin to realize are bound up in matter.

Our study of matter has led us to teach that it manifests itself in some seventy distinct and separate forms which we call elements, and yet our very definition of an element is a confession of our failure. An element is something which we have not been able to decompose into anything simpler. We have discovered some curious and interesting relationships between the elements which point to their common origin. In his heart each one of us believes that they must have had a common origin and that the cycles of development which they exhibit can only have resulted from the action of a periodic variable upon a constant, and yet we very rarely even consider the question of their genesis or why their properties are what they are. We are content to regard them as so many distinct creations. The discovery of a new element is hailed as marking an epoch in the history of our science when our real business should be the elimination of the elements as such.

In their interactions, the elements, as we know them, manifest valences and selective affinities which determine the course of all chemical change and yet we are without an acceptable working hypothesis of the cause and nature of either valence or chemical affinity. Our ideas regarding the constitution of the molecules of many compounds have been developed in great detail and have led us to so many happy conclusions which the facts have verified as to justify our belief that these ideas must rest upon a substantial basis of truth. This sometimes leads us to forget that the graphic formulas which we build up and write on a plane surface are an attempt to represent in terms of two dimensions actualities which exist in three. Moreover, these formulas depict the molecule as something fixed and rigid although everything tells us that

the atoms within the molecule are in rapid and ceaseless motion. A new chemistry will dawn when we take proper cognizance of these notions and their influence upon the properties and relations of the compound. We state molecular weights with a finality of assurance, forgetting that we know very little of the molecular weights of liquids and nothing of the molecular weights of solids. We write cellulose as $(C_6H_{10}O_5)_n$ but the unknown n is probably the most significant part of the entire formula.

Sulphur passes before our eyes, from the crystalline to the amorphous variety, phosphorus assumes the red or yellow form, and an almost complete change of properties attends the transformation. Carbon exists in several markedly different states, and yet as to the meaning and mechanism of these molecular changes we remain in complete ignorance. Fortunately for the comfort or even the very fact of our existence upon the planet water is denser at 4 deg. than it is at zero. Had it not been so our lakes and oceans would be simply so many solid ice masses upon which the summer sun could make only a superficial impression; but in spite of the paramount importance of the fact itself no one of us can say why the water molecule presents this curious anomaly. We write the water molecule as H_2O and commonly regard it as a relatively simple compound. How then shall we account for the fact that the dielectric constant or specific inductive capacity of water is about fifty times that of air, or perhaps ten times that of glass. As the dielectric constant is in a sense a direct measure of the massiveness of the molecule, are we not forced to the conclusion that the water molecule really is built up of many of these H_2O groups? How else indeed shall we explain the power of water to knock asunder the molecules of electrolytes which it dissolves, and does not this complexity of the water molecule bear some relation to the essential part which water plays in the ultimate phenomena of living matter?

And this brings me to the main point of my thesis. A great German chemical company tells us in an attractive book just issued that it employs 218 chemists, 142 civil engineers, 918 officials, and nearly 8,000 workmen. It covers an area of 220 hectares, has 386 steam engines, 472 electric motors, and 411 telephone substations. The plant represents the highest development which industrial chemistry has reached, but none the less it cannot produce an ounce of starch which a potato growing in the ground fabricates from water and carbonic acid gas under the influence of sunshine. True it is that this great aggregation of engines and dynamos, furnaces, retorts, and stills can, under the direction of its highly trained and specialized chemical staff produce certain natural products in condition so available and pure as to even improve upon nature, but by what monstrous effort is it accomplished? In the spring the tender grass and the delicate unfolding leaves cover the whole earth with the green of chlorophyll. There is no noise, no smoke, no stench. The grass is cool and grateful to the touch and clean. In similar manner vegetation everywhere is fabricating cellulose to the extent of several billion tons each year, and not only cellulose, but all the countless other complex products of the vegetable cell. What shall we say of our own chemistry in the face of facts like these, except that we have gone far enough to encourage a faint hope that we may some day be able to approach such methods? Prof. Wheeler has defined so clearly a thought which has been in my mind for years that I cannot do better than quote his words. He says:

"The vegetable cell is a laboratory in which are carried out a most remarkable series of chemical reactions. As we contemplate the immense number of organic compounds of all degrees of complexity which are formed within this wall of the plant cell we are convinced that this is the chemical laboratory *par excellence*. Two features impress us particularly; first the silence in which the operations are carried on; second, the narrow range of medium temperatures required. Notwithstanding this apparent simplicity of conditions, the products are of the most various kind. Some of these man is able to synthesize in his own crude way; others are still the secrets of nature. It is utterly impossible for man to prepare certain naturally occurring compounds except at a temperature which would burn the plant tissue. We are led to wonder whether forces exist with which we are unacquainted or whether we are merely unable to control the forces already familiar to us. It would be difficult to say which supposition is the more prob-

able. It will be granted that investigation into the activities of the cell is of profound importance. In fact it has been said that "It is in the plant cell, where synthetical operations are predominant, that we have to look for the foundation of the 'New Chemistry' which may be expressed broadly as the relation of matter to life."

I expressed two years ago my own belief that the distinctions which we now regard as fundamental between living matter and dead matter would soon break down. This break will in my opinion come through the study of the colloids, which are the link between matter which we regard as living and that which we regard as dead. At this point, I cannot refrain from volunteering a suggestion. We know that the atoms within the molecule are in rotation. It must follow that as the complexity of the molecule increases, more and more of its motion of translation must be converted into rotary motion. In the colloidal molecule we know that many simpler molecules are linked together, and in the molecule of living matter, what? May it not be merely that the more or less haphazard and confined movements of the molecules which together build up the colloid are in the molecule of living matter co-ordinated and controlled in a manner which suggests the vortex? Dead matter drawn within this vortex would partake of this movement and exhibit the phenomena of life. Matter thrown off tangentially would resume its rectilinear course and become, for the moment dead.

When we consider that in theory at least, in which accidents are barred, a tiny bit of living jelly, an amoeba, for example, can endow with life an ocean of its proper pabulum, it seems obvious that the forces which are to manifest themselves in the phenomena of life are already existent in the pabulum and that what the living jelly does is to induce a co-ordination and direction of the atomic movements which then take on the vital aspect. Do we not have something roughly analogous to this in the magnetization of successive pieces of steel drawn across a lodestone? A certain co-ordination of movement in the molecules of the steel has been induced and magnetism results. So in some manner far more complex life I believe may be epitomized as co-ordinated motion.

The subject matter of such speculations lies so far outside our present-day chemistry as to almost require apology for their presentation, but they are well within the subject matter of the chemistry of the future. For, to again quote the words of Pearson: "The goal of science is clear, it is nothing short of the complete interpretation of the universe." Or, as Muir has put it: "The great business of chemistry is to force men into close contact with some aspects of external realities and, with the help of her sister sciences, to remove everything that prevents the full vision of nature."

CAOUTCHOUC AND ARTIFICIAL RUBBER.

IN these days it is not Thomas and Richard and Henry, not the poor lithographer writing a wash-list, nor the poor potter ripping up his kitchen floor for fuel to heat his kiln, who make inventions, and particularly imitative inventions, that is, for the production of new and cheap materials to supplant the old and well-known which have become scarce, or at least the subject of monopoly, either of which causes makes them dear. Now-a-days many important inventions are made by trained and educated specialists, who start in to obtain some wished-for result, and who exhaust all the mechanical, electrical, and chemical possibilities to attain the desired end.

The substitution of one material for another is desirable, when the substitute is cheaper, or more easily attained, than the original, and is sold as such; also when it is just as good or even better.

The production of artificial indigo has been for Germany a long-wished-for achievement; its technical attainment cost years of labor, and this and its commercial development millions of money; and while it may lead to distress and perhaps famine in some parts of British India, it brings back more millions to the inventor's firm and country.

Artificial camphor is a product which has relieved the civilized world of a great tension; for Japan had it in her power to maintain an absolute monopoly of this material, so necessary to the manufacture of celluloid, smokeless powder, and other products, to say nothing of its medicinal virtues.

In connection with artificial "India rubber" (India

no longer, even with a small i, since Brazil, Mexico, and many other countries that are in neither the East nor the West Indies produce it in greatest quantities; and "rubber" only as a detail) Gustav Vogt has an interesting article in the *Gummi Industrie*. In this he calls attention to the fact that the newest discoveries—not inventions, as he adds—are in the line of rubber-producing plants. Mexico has long ago successfully sought after a plant to replace on a commercial scale the guayule, and has found this in a tree, the *paolo colorado*, the juice of which is said to contain 33 1/3 per cent of pure caoutchouc. Although the experiments made with this new "rubber" source have not yet been concluded, they seem to justify the hopes based thereon for the industries, as those who have undertaken them have secured considerable areas of land for the purpose of planting the trees and winning the juice commercially.

That the attempts to produce artificial substitutes for caoutchouc have not been entirely unsuccessful is well known. For instance, a process has been patented in Germany, covering nothing less than the manufacture of a rubber substitute from glue, glycerin, and chrome salts, to which are added "lead plaster," vegetable fibers parchmented by means of acids, gum tragacanth, vegetable balsams, or water-glass. The "lead plaster" should, among other effects, have that of preventing the anhydrous glue composition from saponifying at once on the addition of the chrome salts, which would otherwise create difficulty in casting the mass in thin strips.

Then there went through the technical papers the news that an invention had been made of no less importance than the last mentioned, namely, the transformation of naphtha into caoutchouc, and which is at present being tested on a large scale in the Caucasus, and that the work is long since past the mere experimental stage. This new caoutchouc substitute is said to have many advantages, as it is in the first place much cheaper than the natural "rubber," and secondly, it is fully equal to the real for most industrial purposes. There are some unimportant differences which, Herr Vogt says, are readily perceptible; for instance, a very much lower specific gravity; but from what the writer learned in practically handling the real material a generation ago, he is convinced that the public will never notice any difference, at least as long as the supply of barytes, soapstone, and other weight-adding materials does not give out. A company with ample capital is stated to have been formed to develop the new industry.

Then the latest patent specifications show some new English rubber substitutes or surrogates. (As these, however, are intended to be used as filling for rubber tires, they might really be called substitutes for air.) To satisfy a not unjustifiable curiosity, the formula is here given: Oxidized oil and gum are warmed until the latter is dissolved, permanganate of potash is added, the whole heated to 205 deg. C., finely divided rubber added, and the resulting mixture well stirred.

Most readers of these lines know that glycerin, to

which glue has been added, makes a mass which is elastic under compression, and which somewhat resembles india rubber. The same is true of molasses and glue; and such compounds are used for printer's ink distributing rollers, as molds for under-cut plaster casts, etc. The glycerin and glue mass is used in manufacturing what the German custom-house calls "children's" toys, dolls' heads, animal figures, and like articles.

The latest, however, says Vogt, is the manufacture of india rubber from clay; but as he gives no information whatever concerning it, this is probably such a late arrival that the train has not yet been unloaded and the boxes opened.

Recently there was an announcement that two experts in Burton-on-Trent, England, Mr. Allsebrook and Dr. Docherty, had succeeded in producing caoutchouc by synthesis. At first they met with the usual fate of inventors, ran against doubt at every turn, were laughed at and characterized as fools who were spending their time running the impossible. This, however, did not hinder Dr. Docherty from sending his preparation to experts in Birmingham and Glasgow. Now the *Daily Mail* brings the news that the new invention has received the most unqualified approval of the experts, who declare unanimously that the artificial preparation is as good as the real, and may be characterized as having "arrived" in every sense of the word. If this be true, the invention has a wide field, and should prove of immense value to the scientific and industrial world.

DIRIGIBLE BALLOONS.

THEORETICAL SPECULATIONS.

BY PROF. HEINRICH VON HELMHOLTZ.

Although we can express the laws of motion of liquids and gases in the form of differential equations, we are not yet able to obtain complete integrals of these equations and thus to calculate the resistance offered by air or water to a moving body of complex form.

Yet it is very essential to take the magnitude of this resistance into account in the construction of ships and balloons propelled in any manner. In such cases the resistance opposed by the fluid to the oars, paddles, screws, and other organs of propulsion constitutes the propulsive force, and the resistance opposed by the same fluid to the body of the vessel constitutes the retarding force. The speed attainable by the vessel depends upon the ratio between these two forces.

For ships we have a great mass of empirical experiences, obtained with vessels of the most diverse forms. We know how much work must be done in order to give a ship or boat any desired velocity by means of oars, paddle wheels, or screw propellers. It may be assumed, furthermore, that approximately the most advantageous forms and dimensions, both of hulls and of organs of propulsion, have already been discovered. For airships, on the contrary, we have only the models offered by birds and a few experiments with balloons, which have not been very successful.

In this paper I will endeavor to show how, by a suitable adaptation of the hydrodynamical equations, the experimental results obtained with ships can be applied to analogous problems in aerial navigation.

The hydrodynamical equations enunciated by Euler and subsequently modified by the inclusion of fluid friction by Napier, Poisson, and Stokes have hitherto furnished few results of practical value, because their integrals can be found for only a few of the simplest cases of motion. In many cases, indeed, the equations appear to give erroneous results. These cases include all those in which the stream of fluid bends round a sharp edge. In a former paper (*Monatsberichte der königliche Akademie der Wissenschaften zu Berlin*, April 23d, 1868) I proved that the discrepancies between the calculated and the observed results in these cases are due to the fact that, in the theoretical treatment of the equations, no regard has been given to the restriction that the pressure in the interior of a fluid cannot be negative. The equations, however, give negative pressures at all points where the velocity of the fluid is very great. But a continuous fluid motion round a sharp edge must produce an infinitely great positive velocity and an infinitely great negative pressure at the edge. Hence it follows that the motion of a fluid, either a liquid or a gas, round a sharp edge cannot be continuous, but that there is developed, extending outward from the edge, a surface of discontinuity or separation between two portions of the fluid, which have tangential velocities differing by a finite amount (one portion, for example, may be at rest). If this circumstance is taken into account the integration of the hydrodynamical equations,

in the cases in which it can be effected (see Kirchhoff's paper on fluid motion in Borchardt's *Journal fuer Mathematik*, vol. 70), gives forms of motion which agree very well with the results of observation. This investigation first showed the cause of that part of the resistance opposed to a solid body moving through a fluid that increases in proportion to the square of the velocity.

I remark, further, that the surface of separation mentioned above is in a condition of unstable equilibrium and has a tendency to roll up into vortices. The discontinuous character of fluid motion is most frequently and most easily detected by the appearance of such vortices. I remark, also, that gases differ from liquids in that the volume of the former is greatly affected by changes of pressure. But as we are concerned in this problem only with the unconfined atmosphere, where the air can move freely in every direction, and as it can be shown that small velocities of the wings or propellers produce the best results, it follows that only the variations of pressure that are caused by the accelerations of the moving particles of air need be considered, and these variations of pressure and the variations of volume dependent on them may be neglected so long as the velocities produced remain negligible in comparison with the velocity of sound. This may always be presumed to be the case in the motions here considered and hence we may neglect the variations in the density of the air and treat the latter as if it were an incompressible fluid.

In the following equations and discussions u, v, w denote the components of equilibrium of the fluid parallel to three axes of rectangular co-ordinates, and p denotes the pressure and ρ the density of the fluid, at the time t , at the point whose co-ordinates are x, y, z . The coefficient of friction is denoted by k . The equations of motion of an incompressible fluid are:

$$\frac{du}{dx} + \frac{dv}{dy} + \frac{dw}{dz} = 0 \dots\dots\dots 1$$

$$-\frac{1}{\rho} \frac{dp}{dx} = u \frac{du}{dx} + v \frac{du}{dy} + w \frac{du}{dz} - K \left\{ \frac{d^2 u}{dx^2} + \frac{d^2 u}{dy^2} + \frac{d^2 u}{dz^2} \right\} \dots\dots\dots 1a$$

with two other equations derived from 1a by substituting v for u and y for x , in one case, and w for x and z for y in the second case.

In addition, we have the limiting conditions at the surface of the immersed body and at any other solid walls that may be present. In most cases we may regard the particles of a fluid in which friction exists as adhering to solid surfaces in contact with them. In other words, the analytical expressions of the values of u, v, w for the stratum of fluid in contact with the solid are identical with those of the values of u, v, w for the superficial particles of the solid.

Now, if we have obtained, by theory or experiment, for any kind of fluid motion, values of u, v, w which

satisfy the conditions specified above, and if we then consider another fluid in which the coefficient of friction is K and the density F , and if we denote by U, V, W the components of flux, and by P the pressure at the time T at a point in this second fluid of which the co-ordinates are X, Y, Z , and if we assume that

$$K = qk \dots\dots\dots 2$$

$$E = re \dots\dots\dots 2a$$

$$U = nu \quad X = \frac{q}{n} x$$

$$V = nv \quad Y = \frac{q}{n} y$$

$$W = nw \quad Z = \frac{q}{n} z$$

$$P = n^2 r \quad T = \frac{q}{n^2} t$$

in which q, r , and n are constant factors, then the quantities denoted by capital letters will satisfy the system of conditions already established for the quantities denoted by small letters. This may be proved by substituting capitals for small letters in the equations of motion, 1 and 1a, and then substituting for the capitals their values as expressed in the ten equations just given. The effect of these substitutions is to reproduce the original equations, except that both

members of equation 1 are multiplied by $\frac{q}{n^2}$, and both members of equation 1a are multiplied by $\frac{q}{n^3}$, and these

common factors may be omitted. Of the constants q, r , and n , q and r depend upon the properties of the two fluids and are given by the equations 2 and 2a, but n is arbitrary.

Hence the linear dimensions are multiplied by $\frac{q}{n}$ in

the case of the second fluid and the solid bodies immersed in it must be conceived as magnified in the same ratio, in order to satisfy the surface conditions.

As the surfaces are proportional to $\frac{q^2}{n^2}$ and the pressures to $n^2 r$, the total pressures exerted on corresponding surfaces must be proportional to $q^2 r$. The energy expended in a unit of time in maintaining the motion of the surface is equal to the product of the velocity of the surface by the total pressure opposed to it. Hence, as the velocity is proportional to n and the total pressure to $q^2 r$, the rate of expenditure of energy is proportional to $q^2 n r$.—*Zeitschrift des deutschen Vereines zur Foerderung der Luftschiffahrt*, 1885.

AIRSHIP HARBORS.

AN IDEA FOR DIRIGIBLE BALLOON INVENTORS.

BY F. W. ILGES.

EVEN the opponents of the rigid system of construction for airships must admit, after Count Zeppelin's latest exploit, that a rigid airship may be able not only to follow an arbitrary course with great speed to a definite goal and to fly at a height more or less independent of its buoyancy, but also to make long flights and to land in safety on solid ground by means of its own unaided power. The fact that Zeppelin had previously confined his experiments to the Lake of Constance naturally led to the inference that he foresaw great difficulties in the way of making a landing on solid ground.

Even after the easy landing in a field near Echterdingen had silenced the doubts in regard to this point, a new doubt was expressed—whether a light and fragile airship, offering a large surface to the wind, could live through a storm while in contact with the ground.

The unfortunate accident, in which the noble vessel, soon after it had made its first successful landing on solid ground, was destroyed by the elements in a few seconds, seems to justify this apprehension. Hence it is not surprising that the opponents of the

points, fixed harbors so designed that the airship can safely be brought under shelter even in bad weather. These harbors must be of inexpensive construction, if airships are to be extensively used. It seems to me that both of these requirements can be met by abandoning the great iron building with a narrow opening at one end through which the long airship must be carefully steered, and substituting a simple excavation in the earth, somewhat larger than the airship in length, breadth and depth. Into such an "earth harbor" the airship could be hauled down from the air very easily without traversing any narrow passage. By employing additional ropes, properly placed, it should be possible to perform this operation safely even in a storm. Then a light and nearly flat roof, which had been temporarily moved out of the way by means of wheels and rails, could be rolled back into place, and the airship would be perfectly protected from the weather.

The details of arrangement and construction of the earth harbor would vary according to circumstances. If it is to serve only as an occasional refuge in time of danger it will be sufficient to make an excavation of

are sulphides, sometimes mixed with oxides and metallic copper.

The Ashio mine, near Nikko, and seven smaller mines, are operated by the Furukara Mining Company. The largest vein is 3,300 feet long and 5 or 6 feet thick. Here the sulphide is associated with pyrites, blende, galena, and mispickel. The equipment is very modern and has a capacity of 700 tons of ore per day. It includes blast furnaces, converters, electric refining, and a 5,000-horse-power electric generating station, operated by water power. More than 6,000 tons of copper were produced in 1907.

The Beshi mine in the island of Shikoku has been owned by the Sumitomo family for two centuries. The ores are sulphides of copper and iron, with a little arsenic, cobalt, manganese, and lead. They contain 4 or 5 per cent of copper and are reduced in the blast furnace and reverberatory furnace; 5,000 tons of copper were produced in 1907.

The Kosaka mine, in the northern part of Nippon, operated by the Fujita Mining Company, is the most important of all. The ore is a mixture of the sulphides of copper and iron with blende, galena, and a little silver and gold. It contains 2 or 3 per cent of copper, 18 to 30 of sulphur, and from 5 to 50 of silica. Mechanical preparation is impossible and the treatment is very difficult and complex. It includes: 1. Roasting of the crude ore in the reverberatory furnace. 2. Smelting, with the production of a matt containing 30 per cent of copper. 3. Smelting with a flux of auriferous barium silicate, yielding a 49 per cent matt. 4. Roasting in a Herreshoff furnace. 5. Reduction to crude copper in the reverberatory furnace. 6. Electrolytic refining. There is a 3,000-horse-power electric generating station, operated by water power. From 80 to 85 per cent of the copper contained in the ore is extracted, and nearly 3 tons of silver and 6 or 7 pounds of gold are obtained monthly. The annual production of copper rose from 85 tons in 1896 to about 7,500 tons in 1907.

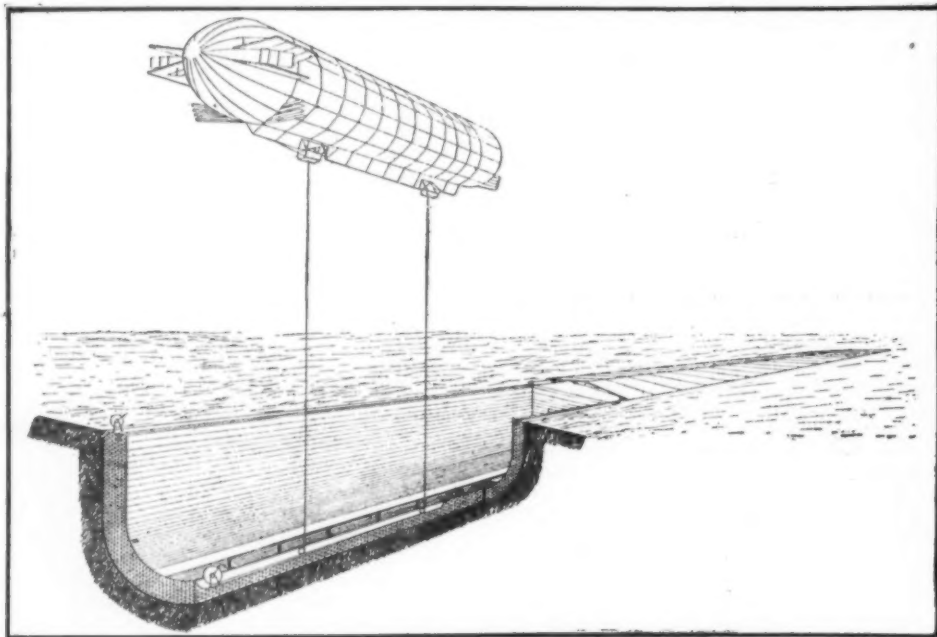
The Kano and Kune mines, now unimportant, will rank among the chief copper mines in Japan when their new equipment is completed.

In 1907 the exports of copper amounted to nearly 32,000 tons, of which about 14,000 tons went to Europe, 3,500 to America, 1,400 to China, and 400 to India. Freight charges per ton are about \$5 to America and \$6.25 to Europe.

TESTING PAPER MATERIALS.

ALL materials used in paper making should be tested. Wood pulp should give a neutral reaction with litmus paper, and the percentage of gypsum should be determined. Absorbent pulp from deciduous trees should be tested in regard to the height to which it will draw water. Pulp for photographic papers must, after a preliminary treatment with ammonia, be tested for metallic iron with potassium ferricyanide (red prussiate) and acids, and for oxide of iron with potassium ferrocyanide (yellow prussiate) and acids. Lead salts can be detected by the blue-violet color which they give to starch paste and potassium iodide. Straw pulp is tested for permanence of whiteness by soaking it for a long time in very dilute solution of ammonia. The pulp which remains white longest is the best. Ground rags should be examined with a microscope for fineness and adulteration with shavings. All of these materials must be tested for moisture by heating to the boiling point. The color of rosin should be tested by comparison with iodine solutions of known strengths. The pale yellow rosin which does not exhibit a conchoidal fracture is unfit for use. Good rosin should saponify completely. Greek rosin is sometimes adulterated with cherry gum, which is not completely saponifiable.

One of the landmarks of Paris is soon to disappear. This is the Galerie des Machines, about which there was a great deal of discussion in the Municipal Council. A movement was made to have it set up in the drill grounds of Issy-Moulineaux, but this could not be carried out. After a long series of negotiations between the city of Paris and the state, it was decided to demolish the immense iron structure, and the building was awarded to the highest bidder, a contracting firm, for the sum of \$130,000, and it will be converted into old iron, to the disappointment of many who admired the great proportions of the structure.



A PROPOSED "EARTH HARBOR" FOR AIRSHIPS.

rigid system regard the catastrophe, not as the work of chance, but as a confirmation of their theories.

It must be admitted that the problem of protecting the rigid airship, while on land, from injury by storm and lightning is not yet solved, and it appears questionable whether it can be solved completely with the aid of shelters of the type of the structure on the shore of Lake Constance. The disaster at Echterdingen could scarcely have occurred if the airship had been sheltered in a strongly constructed building, but the vessel could not have been brought into the building in stormy weather. Even in the experiments on Lake Constance the airship did not escape injury in the process of housing, and on solid ground the conditions of careful handling by a large and well-trained crew and, above all, calm weather are required to house a fragile airship more than 300 feet long, without injury, in a shelter of this type. So long as the airship remains in the air it is almost independent of the weather, except for the chance of being struck by lightning. Even if the motors cannot make head against the storm the worst that can happen is for the vessel to be carried away before the wind. The danger of immediate and total destruction does not appear until after the vessel has abandoned its proper element, the air, and, instead of riding the storm, is anchored to the earth and exposed to the full power of the elements. In landing on water it is possible to anchor the airship at the bow, so that it will turn with the wind and present to the latter only the comparatively small surface of the bow. The possibility of adapting this method to a land anchorage, by receiving the airship on a wheeled carriage, is open to question.

Hence it will be necessary to establish, at many

the type of a fortification trench, with earth walls held together by growing vegetation. The roof might be omitted or it might be a light frame of wood or aluminium, covered with sail cloth, and moved by hand. For this simple type of harbor a high and dry site should be selected. On the contrary, a harbor designed for regular use as a station for aerial traffic should be lined with masonry or cement and provided with stairs, lifts, electric light and power, a searchlight, and a strong roof of iron and glass, moved by an electric motor.

The comparative cheapness of the underground harbor is a point of great importance. The cost of the simplest overground emergency shelter would be very many times greater than that of a simple ditch with walls of turf, and the permanent earth harbor with its sliding roof and complete equipment would cost much less than an overground airship hall of the railway terminus pattern.—Umschau.

THE PRODUCTION OF COPPER IN JAPAN.

THE production of copper is an ancient industry in Japan, and within the last half century it has been greatly developed by the introduction of modern methods, which the Japanese have mastered so thoroughly that all the mines are in Japanese hands. Japan is now the second in the list of copper producing countries, being surpassed only by the United States. The annual production rose from 4,800 tons in 1881 to 40,000 tons in 1907, not through the discovery of new mines but through the more intensive working of long-known deposits. Three hundred mines are being worked, but only fifteen are of great importance, and three furnish half the total product. The ores

HOW TO TRISECT AN ANGLE.

MECHANICAL SOLUTIONS OF AN OLD PROBLEM.

BY A. AUBRY.

THE mechanical solutions of the celebrated problem of the trisection of the angle which are succinctly presented in this article are effected by combinations of rods turning about joints or guided by pegs and slots. Devices which employ curved guides involve a begging of the question, as the curve must have been previously traced, either by points, in which

same class (Fig. 6) and several other devices, including those represented by Figs. 7, 8, 9, and 10.

Let MOB (Fig. 7) be the angle to be divided, and lay off OA equal to OB and in the opposite direction. Draw a T on tracing paper and, on one of its branches, lay off LM equal to OB . Lay the tracing paper on the angle so that M falls on OM , the other branch of

tacts and are, consequently, not very accurate. Greater precision can be obtained with instruments involving joints only.

The compass invented by Sylvester in 1874 (Fig. 11) solves the problem in the most elementary manner, but it contains fourteen rods, of which seven meet at one joint. The instrument could be simplified by suppressing the parts to the right of OI , and connecting A and E , by equal rods, to a point P , not indicated in the figure, but still simpler and more convenient instruments have been based on Sylvester's theory of articulated systems. For example, Peaucellier's trisector (Fig. 12) is composed of a rhomb CD , two equal rods CO and DO , and two other rods EO and AE , each equal to $\sqrt{OC^2 - BC^2}$. In every position of the instrument $BE \cdot O = 1/3 BE \cdot F$.

Kempe's trisector is a combination of three similar contraparallelograms, $EDOC$, $B'COB$, and $A'BOA$, in which by the definition of similar contraparallelograms, $OD = EC$, $ED = OC = B'B$, $B'C = OB = OC$, $A'A = OD$, $A'B = OA = OC$. The three angles at O are equal. This apparatus, like Lansant's (Fig. 5), has the grave defect of requiring a quadruple joint at the apex of the angle. It can be simplified as indicated in Fig. 14, which represents a combination of two contraparallelograms and a small rhomb. Here $LOM = 1/3 AOM$.

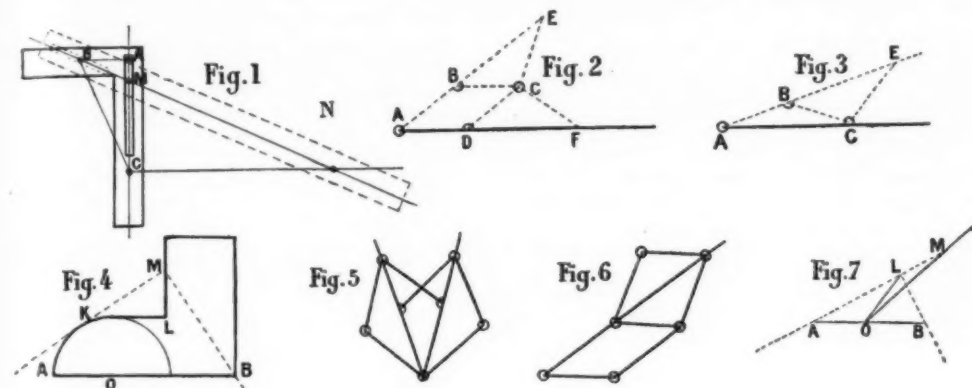
The instrument shown in Fig. 15 is still more practical. The lengths of the rods are $AO = OB = OF = CB = DF = 2$, $AD = DF = \sqrt{5} + 1$, $BE = EF = CD = \sqrt{5} - 1$. Then $BOC = 1/3 COA$.

The device indicated in Fig. 16 divides the angle directly, and its sides remain visible, which makes the operation very convenient. Here $OB = BD = ED = AF = BC = 1$, $AO = FE = CE = \sqrt{5} - 1$, $CG = AB = \sqrt{5} + 1$, and $COB = 1/3 COE$.

Figs. 17, 18, and 19 show trisectors containing only six rods each. The lengths of the rods are marked on the figures. In Fig. 17, $AGM = 1/3 BGM$; in Fig. 18, $GOB = 1/3 BOH$; in Fig. 19, $GOE = 1/3 GOC$, E being the middle point of BD .

I have devised a great many trisecting instruments and many more might be invented, but the foregoing list may suffice.

It is a remarkable fact that the simplest trisectors are based upon the most abstruse mathematical principles, while Sylvester's compasses (Fig. 11) with its



case the solution is not of a mathematical character, or with an instrument which in this case is the real trisector.

Alleged geometrical solutions, employing parabolas, spirals, cycloids, conchoids and other curves, were discovered by ancient geometers. The first mechanical solution was obtained by Nicomedes with an apparatus called a conchoidograph. It may be presented as follows: Let ABC (Fig. 1) be the angle to be trisected. A draftsman's square having a peg on one arm and a slot in the other is applied to the drawing so that the peg falls on the apex of the angle B , and the slotted arm is perpendicular to the line AB . A straight ruler, having a peg M and a short slot near one end, is so applied that the peg B of the square enters the slot of the ruler and the peg M of the ruler enters the slot of the square, and the ruler is moved, until a second peg N , distant from M by twice the length BC , falls on the line CN , perpendicular to AC . The angle ABN is the required third part of ABC .

This instrument exists only in theory. In practice the ruler may be represented by a strip of tracing paper, marked with two dots, M and N , and a line joining them and extended. On one of the sides of the given angle B lay off $BC = 1/2 MN$. Draw CA perpendicular and CX parallel to the other side of the angle. Apply the strip to the drawing so that the prolongation of MN falls on B , M on CA , and N on CX . Mark the position of N or CX , and draw BN .

Nearly eighteen centuries elapsed before a second mechanical solution was found, although the geometrical principle of that solution, and of the two which follow it in this article, was discovered by the Arabian mathematician Aboul Djoud. The "Acta Eruditorum," published in 1696, contains a description of an instrument invented by Ceva, and composed of six rods connected by joints (Fig. 2). The rods CE , CB , CD , and CE are equal to each other and to the parts AB and AD of the rods AE and AF . The ends E and F of the rods CE and CF slide on the rods AE and AF . In any position of the instrument the angle at A is equal to one-third ECF . (Joints are indicated by circles in all the figures.)

In 1707 Marquis de l'Hospital extended this solution to the division of the angle into any number of equal parts, by completing the rhomb EF , and in 1875 Perrin reduced it to the simpler form indicated in Fig. 3.

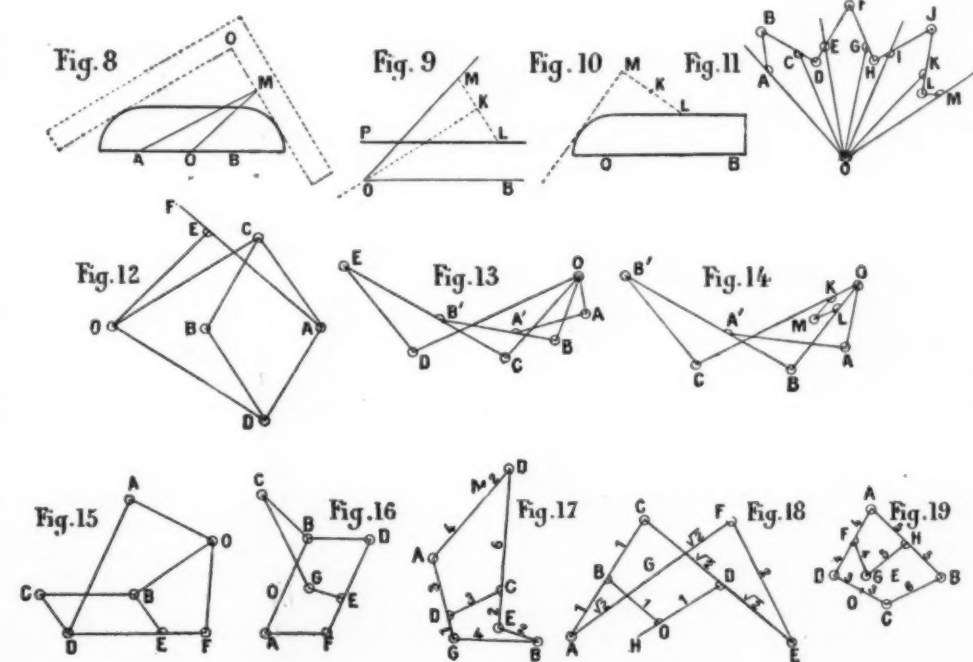
The device illustrated by Fig. 4 was proposed by Bergery in 1835. It is composed of a semicircle joined to a rectangle, of which the base is equal to the radius OA . The angle to be divided is placed with its apex on LM , one side tangent to the semicircle and the other side passing through the corner B of the rectangle. Then $LMB = 1/3 KMB$.

In 1875 Laisant invented an instrument composed of two jointed rhombs, with one joint in common and the opposite joint of each rhomb sliding on a prolonged side of the other (Fig. 4). The angle inclosed by the inner pair of the rods meeting at the common joint is one-third of the angle inclosed by the outer pair. In 1896 I suggested a simpler apparatus of the

the T passes through A , and the stem through B . Then LOM is the required third part of MOB . The T might be made of wood or metal and caused to slide on two fine pins fixed at A and B , but it would be difficult to make an accurate trisection in this way.

Much better results could be obtained with the apparatus illustrated by Fig. 8, in which a draftsman's square OM moves with its branches in contact with two equal quadrants, connected by a rectangle of a length equal to the diameter of the circle. When $OM = AO$, $AMO = 1/3 MOB$.

In Fig. 9 let MOB be the angle to be divided. Draw PL parallel to OB at a distance equal to the length of either branch of a T square and apply this T square so that its stem passes through O and the ends of its equal branches fall on OM and PL . Then $LOB = 1/3 MOB$. The T square may be replaced by a T drawn on tracing paper. Another modification is shown in Fig. 10, which represents an L square, or traced L , moving with the end of one branch in contact with the upper side of a rectangle, and the other branch tangent to a quadrant. The height of the



rectangle is equal to half the length of the branch, ML , which touches it, and is also equal to the radius of the quadrant. The base of the rectangle coincides with one side of the angle MOB , which is to be divided, and the center of the quadrant coincides with the vertex O . When M , the vertex of the L , falls on the other side of the angle, the required third of that angle is LOB .

The devices described above include sliding con-

fourteen rods and septuple joint is founded on elementary mathematical considerations.—Cosmos.

Caps.—Two pieces of tissue paper are stuck together with some fulminate (chlorate of potash and red phosphorus, mixed with gum water) between them. They detonate on being struck or squeezed with considerable violence and serve as ammunition for toy pistols, sometimes also as igniters.

A SIMPLE METRIC CONVERSION TABLE.

CHANGING METRIC UNITS INTO ENGLISH EQUIVALENTS.

BY WALTER T. SWINGLE.

EVERYONE who has had occasion to convert metric quantities into American units has had ample proof of the fact that such calculations are often difficult and always cumbersome. This is because double conversions are often required, and existing tables are not adapted to such operations. Suppose, for instance, it is required to know the equivalent of a given number of kilogrammes per hectare in pounds per acre; to find this it is necessary first to divide the equivalent of a kilo in pounds by the equivalent of a hectare in acres, and second to multiply the given number of kilos by this quotient. No wonder the average reader goes on without trying to make the calculation. The same roundabout operation is required for the conversion of kilos per hectoliter into pounds per bushel, hectoliters per hectare into bushels per acre, pressure in kilos per square centimeter into pounds per square inch, and for many other measures constantly occurring in technical and agricultural literature, which only too often are left untranslated and only imperfectly realized.

All double conversions such as those noted above are easily performed by a single operation; merely by multiplying by the factors given in the following list. These multiplications are of course made by simple inspection in using a slide rule.

Example: Suppose it is required to convert a yield of grain of 48 hectoliters per hectare into bushels per acre. All that is required is to multiply 48 by 1.1484, the conversion factor given below, making 55.12, the answer in bushels per acre.

I. AGRICULTURAL AND TECHNICAL MEASURES.*

1. Kilogrammes per hectare to pounds per acre, multiply by	0.8922 —
2. Hectoliters per hectare to bushels per acre, multiply by	1.1484 —
3. Hectoliters per hectare to gallons per acre, multiply by	10.6906 +
4. Kilogrammes per hectoliter to pounds per bushel, multiply by	1.2871 +
5. Pressure, kilos per square centimeter to pounds per square inch, multiply by	14.2234 —
6. Kilogrammes per cubic meter to pounds per cubic foot, multiply by	0.0624 +
7. Kilogrammes per cubic meter to pounds per cubic yard, multiply by	1.6855 +

II. FRENCH PRICES (1 franc=19.3 cents).

Francs per hectare to dollars per acre, multiply by	0.078
Francs per hectoliter to dollars per bushel, multiply by	0.068
Francs per kilogramme to dollars per pound, multiply by	0.088 (**)
Francs per meter to dollars per yard, multiply by	0.176 (**)
Francs per liter to dollars per gallon, multiply by	0.731 (**)
Francs per cubic meter to dollars per cubic yard, multiply by	0.1475

III. GERMAN PRICES (1 mark=23.8 cents).

Marks per hectare to dollars per acre, multiply by	0.096
Marks per hectoliter to dollars per bushel, multiply by	0.084
Marks per kilogramme to dollars per pound, multiply by	0.108 (**)
Marks per meter to dollars per yard, multiply by	0.218 (**)
Marks per liter to dollars per gallon, multiply by	0.901 (**)
Marks per cubic meter to dollars per cubic yard, multiply by	0.182

APPROXIMATE DOUBLE CONVERSIONS BY RULE OF THUMB.

Often an approximation such as can be obtained readily by the use of the rules of thumb given below is accurate enough for the purpose in view. In case of yields per acre and other agricultural measures, the rule of thumb will give results within the limit of accuracy of the original measure. The purpose of these rules is to enable the general reader to calculate quickly and without the aid of a slide rule the metric

quantities most commonly encountered in the reading of scientific and technical literature.

At first sight these rules seem complex, but on using them the complexity is found to be in the explanation, not in the operation itself. For the most part the operations are limited either to multiplication or division by some multiple of ten which amounts merely to a change of the decimal point, or else to multiplication or division by some simple integer such as 3 or 4.

The rules of thumb are given first in English, then in algebraic summary, and an example is worked out, first in full according to the summary, and then in abbreviated form as would be done by one accustomed to using the rule.

RULES OF THUMB FOR CONVERSION OF METRIC MEASURES.

1. Kilogrammes per Hectare to Pounds per Acre.

(Conversion factor 0.892182.)

From the number of kilogrammes subtract one-tenth of itself, and from the remainder in turn subtract one-hundredth of itself. This gives the number of pounds per acre to within one pound in 753 (too little).

Summary.

a = kilos per hectare.
 $b = 1/10$ of a .
 $c = a - b$.
 $d = 1/100$ of c .
 $e = c - d$, Ans. in pounds per acre (too small by $1/753$).

Example.

I. Worked out in full.	II. Abbreviated form.
10) 268.4 kilos per hectare.	268.4
26.84	26.84

100) 241.56	241.56
24.156	24.15

239.1444 Ans. pounds per acre (should be 239.462).

1a. Kilos per Hectare to Pounds per Acre (closer approximation).

(Conversion factor 0.892182.)

In case very large quantities per hectare are to be converted into pounds per acre it may be desirable to use the following rule, giving a much closer approximation than the one printed above:

From the number of kilos per hectare subtract one-tenth of itself, and from the remainder in turn subtract one-hundredth of itself, giving the first approximation. Then to the original number add one-tenth of itself, divide this sum by 1,000, and add the quotient to the first approximation. This gives the number of pounds per acre to within 1 in 10,885 (too small).

Summary.

a = kilos per hectare.
 $b = 1/10$ of a .
 $c = a - b$.
 $d = 1/100$ of c .
 $e = c - d$, first approximation.
 $f = a + b$.
 $g = 1/1,000$ of f .
 $h = e + g$, Ans. in pounds per acre (too small by $1/10885$).

Example.

268.4 kilos per hectare.	268.4
26.84	26.84
241.56	295.24
24.156	.2952 = g

239.1444 first approx.

.2952

239.4396 Ans. pounds per acre (should be 239.4616).

2. Hectoliters per Hectare to Bushels per Acre.

(Conversion factor, 1.148398.)

To the number of hectoliters per hectare add one-tenth of itself and one-half of this tenth. This gives the number of bushels per acre to within one in 717 (too much).

Summary.

a = hectoliters per hectare.
 $b = 1/10$ of a .
 $c = 1/2$ of b .
 $d = a + b + c$, Ans. bushels per acre (too large by $1/717$).

I. Worked out in full. II. Abbreviated form.

10) 266.5 hectoliters per hectare	266.5
2) 26.65	26.65
13.325	13.325

306.475 Ans. bushels per acre (should be 306.048).

3. Hectoliters per Hectare to Gallons per Acre.

(Conversion factor, 10.690642.)

To the number of hectoliters per hectare add ten times itself and from the sum subtract one-third of the original number. This gives the number of gallons per acre to within one part in 446 (too small).

Summary.

a = hectoliters per hectare.
 $b = 10$ times a .
 $c = a + b$.
 $d = 1/3$ of a .
 $e = c - d$, Ans. gallons per acre (too small by $1/446$).

Example.

I. Worked out in full.	II. Abbreviated form.
87.6 hectol. per hectare.	876.0
876.0	87.6

963.6	963.6
29.2	29.2

934.4 Ans. gals. per acre (should be 936.5).

In using the shortened form the product obtained by multiplying the original number by 10 is written above this number so the latter can be divided by three without rewriting.

3a. Hectoliters per Hectare to Gallons per Acre (closer approximation).

(Conversion factor, 10.690642.)

When large yields are to be converted from metric to American measure the following rule may be followed; it gives a much closer approximation than the rule given above:

To the number of hectoliters per hectare add ten times itself for the first approximation; then take one-tenth of the original number, multiply it by 3, and to the product add one-hundredth of the original number; finally subtract this sum from the first approximation. This gives the number of gallons per acre to within one in 16,723 (too small).

Summary.

a = hectoliters per hectare.
 $b = 10$ times a .
 $c = a + b$, first approximation.
 $d = 1/10$ of a .
 $e = 3$ times d .
 $f = 1/100$ of a ($1/10$ of d).
 $g = e + f$.
 $h = c - g$, Ans. gallons per acre (too small by $1/16,723$).

Example.

87.6 hectoliters per hectare	8.76
876.	3

963.6, first approx.	26.28
27.156	.876

936.444 Ans. gallons per acre (should be 936.500).

4. Kilogrammes per Hectoliter to Pounds per Bushel.

(Conversion factor, 1.287133.)

To the number of kilogrammes per hectoliter add one-fourth of itself and one-tenth of this fourth. This gives the number of pounds to the bushel to within one part in 106 (too small).

Summary.

a = kilos per hectoliter.
 $b = 1/4$ of a .
 $c = 1/10$ of b .
 $d = a + b + c$, Ans. pounds per bushel (too small by $1/106$).

Example.

4) 49.8 kilos per hectare.	12.45
1.245	

63.49 Ans. pounds per bushel (should be 64.039).

Inasmuch as it is very difficult to determine accurately the exact weight of grain, etc., in a given measure of volume, it is believed that the above approximation is sufficiently accurate for all ordinary purposes.

*The paragraphs under this first division are numbered to correspond with the rules of thumb (to be given below) for making these same conversions.

**Tables of Equivalents of the United States Customary and Metric Weights and Measures, third edition, 4to, pp. 1-50, Washington (Bureau of Standards), November 1, 1906.

4. Kilogrammes per Hectoliter to Pounds per Bushel (closer approximation).

(Conversion factor, 1.287133.)

In case greater accuracy is required than is given by the above rule of thumb, for example, in calculating the legal weights per bushel of various grains, etc., the following modification, giving very great accuracy, may be employed:

To the number of kilogrammes per hectoliter add one-fourth of itself for the first approximation; then to this sum add one-tenth of the fourth just calculated above and one-hundredth of the first approximation itself. This gives the number of pounds per bushel to within 1 in 3,507 (too large).

Summary.

a=kilos per hectoliter.

b=1/4 of a.

c=a+b.

d=1/10 of b.

e=1/100 of c.

f=c+d+e, Ans. pounds per bushel (too large by 1/3507).

Example.

4)49.8 kilos per hectoliter.

12.45

62.25 first approx.

1.245

.6225

64.1175 Ans. pounds per bushel (should be 64.0992).

5. Pressure in Kilogrammes per Square Centimeter to Pounds per Square Inch.

(Conversion factor, 14.223398.)

Multiply the number of kilogrammes per square centimeter by 10, divide the product by 2, and add the quotient to the product to obtain the first approximation; then divide the first approximation by 20 and subtract this quotient from the first approximation. This gives the pressure in pounds per square inch to within one part in 535 (too large).

Summary.

a=pressure in kilos per square centimeter.

b=10 times a.

c=1/2 of b.

d=b+c, first approximation.

e=1/20 of d.

f=d-e, Ans. pounds per square inch (too large by 1/535).

Example.

I. Worked out in full.

38.7 kilos per sq. cm.

2)387

193.5

20)580.5 first approx.

29.025

551.475 Ans. pounds per square inch (should be 550.43).

II. Abbreviated form.

2)387

193.5

20)580.5

29.025

551.47 Ans.

6. Kilogrammes per Cubic Meter to Pounds per Cubic Foot.

(Conversion factor, 0.062428.)

Take one-tenth of the number of kilogrammes per cubic meter, divide by 2 and divide this quotient in turn by 4; add these last two quotients. This gives the number of pounds per cubic foot to within 1 part in 865 (too large).

Summary.

a=kilos per cubic meter.

b=1/10 of a.

c=1/2 of b.

d=1/4 of c.

e=c+d, Ans. pounds per cubic foot (too large by 1/865).

Example.

986.4 kilos per cubic meter.

2)98.64

49.32

12.33

61.65 Ans. pounds per cubic foot (should be 61.579).

7. Kilogrammes per Cubic Meter to Pounds per Cubic Yard.

(Conversion factor, 1.685565.)

To the number of kilogrammes per cubic meter add one-half of itself and one-third of this half for the first approximation; to this sum add one-hundredth of itself and one-thousandth of itself. This gives the number of pounds per cubic yard to within one in 2,581 (too small).

Summary.

a=kilos per cubic meter.

b=1/2 of a.

c=1/3 of b.

d=a+b+c, first approx.

e=1/100 of d.

f=1/1000 of d (1/10 of e).

g=d+e+f, Ans. pounds per cubic yard (too small by 1/2981).

Example.

2)2632 kilos per cubic meter.

3)1316

438.666

4386.666

43.866

4.386

4434.919 Ans. pounds per cubic yard (should be 4436.407).

EXACT CONVERSION OF METERS INTO FEET BY RULE OF THUMB.

By the law of July 28, 1866, the legal equivalent of the meter in this country was fixed as 39.37 inches, and this action has been construed as basing the foot on the standard meter preserved in Paris and not on the yard measure preserved in London, which is the legal standard for England and the British colonies.

One good result of this rather arbitrary interpretation of the law is to make the American foot and the meter exactly commensurable. As will be shown below, it is possible to take advantage of this commensurability in converting meters into feet by a simple rule of thumb.

Rule.

Multiply the number of meters by 10 and divide by 3 for the first approximation; then divide the original number by 20 and the quotient in turn by 20, add the two quotients and subtract the sum from the first approximation. This gives the number of feet exactly!

Summary.

a=meters.

b=10 times a.

c=1/3 of b, first approximation.

d=1/20 of a.

e=1/20 of d.

f=d+e.

g=c-f Ans. feet (exact).

Example.

I. Worked out in full.

4368 meters.	20)4368	218.4
10		10.92
	20)218.4	
3)43680	10.92	229.32 = f

14560 first approx.

229.32

14330.68 Ans. feet (exactly correct).

II. Abbreviated form.

3)43680	20)436.8	
14560	20)218.4	
229.32	10.92	
14330.68 Ans.	229.32 = f	

In working the method by the abbreviated form a zero is added for the multiplication by 10, and in dividing the first time by 20 the decimal point is set over one place to the left in the dividend and the divisor cut down to 2; finally in making the second division by 20 the quotient is set one place to the right, so as to be ready to add to the first quotient without rewriting. This setting one place to the right of the quotient obtained by dividing by 2 gives the right sum if the decimal point is written just under the one above.

With a little practice it is possible to convert meters into feet very quickly, and as the method is absolutely accurate it can be applied to very large numbers. When we reflect that the only alternative without the use of cumbersome tables is to multiply the number of meters by the imperfect number 3.280833333+ it can be realized how much simpler it is to use the rule of thumb.

CARBON TETRACHLORIDE.

CARBON tetrachloride possesses, in comparison with carbon disulphide, benzene, gasoline and other petroleum products used for the extraction of oils and fats, the advantages of freedom from inflammability, which reduces the danger of fire and the cost of insurance, and of small latent heat of evaporation, facility of condensation, great dissolving power and lack of tendency to form emulsions with fats, all of which properties effect economies in the quantity of solvent or of fuel required.

Oil extracted from seeds by means of carbon tetrachloride does not retain any flavor of the solvent, and the oil cake may be fed to cattle.

The action of the tetrachloride on metal vessels is most marked when water is present. The metals least attacked are galvanized iron, copper, cast iron, tinplate, brass and sheet iron, in the order given. Gal-

vanized iron should be employed in the interior of apparatus, but copper or lead pipes and bronze cocks may be used.

Carbon tetrachloride is made by several processes in which carbon disulphide is acted upon by chlorine, directly or indirectly. The direct action takes place only at high temperatures and in presence of catalyzers. In the indirect method sulphur chloride or some similar compound is employed, with or without a catalyzer.

Cote has devised a process and an apparatus for the continuous production of carbon tetrachloride from chlorine, carbon and sulphur. Carbon disulphide and sulphur chloride are formed as intermediate products. The apparatus resembles the continuous distilling and rectifying apparatus of modern spirit distilleries. In one vertical cylinder or "column," which is filled with coke impregnated with manganese chloride, carbon disulphide and chlorine come together and form sulphur chloride, with a little carbon tetrachloride. The mixture flows into a second column, filled with coke impregnated with sulphide of iron, where it encounters a fresh stream of carbon disulphide. The resultant product consists of carbon tetrachloride mixed with a little sulphur chloride and containing free sulphur in solution. This mixture passes into a third column filled with metal balls and heated to 260 deg. F. The carbon tetrachloride and sulphur chloride are immediately converted into vapor in which form they pass into the fourth, or rectifying column, while the sulphur is melted and flows into an electrically heated furnace, where it combines with carbon to form carbon disulphide, which goes directly to the first two columns to recommence the cycle.

From the rectifying column the carbon tetrachloride passes into a vessel where it is distilled, in presence of water, to remove the last traces of sulphur chloride, and thence to a condensing and cooling worm.

An electric furnace is employed because the process was devised especially for the utilization of the chlorine evolved in the electrolytic production of soda.

In a radically different method, invented by H. S. Blackmore, of Mount Vernon, U. S. A., carbon tetrachloride is produced by the action of calcium hypochlorite upon calcium carbide and hydrochloric acid. In practice a mixture of 18 parts of chloride of lime and 3 parts of calcium carbide is exposed to the action of a current of hydrochloric acid gas, diluted with nitrogen in order to moderate the intensity of the reaction. The calcium carbide may be replaced by gaseous or vaporized hydrocarbons which should be mixed with the hydrochloric acid gas and directed upon the chloride of lime. On the other hand, the chloride of lime may be replaced by other oxidizing agents, or even by oxygen, provided that the operation is conducted at a dull red heat, at which hydrogen exhibits a greater affinity for oxygen than for carbon. Carbon tetrachloride is also produced by the action of the electric arc upon a fused mixture of calcium chloride and wood charcoal. The bromide, iodide, and fluoride of carbon can be produced by analogous methods.

Naphthalene is an annoying waste product in gas works, where it condenses in great quantities in the pipes. A small proportion of the product is used to destroy insects and protect fabrics from moths, and this was practically the only use made of the substance when Chenier, in 1904, conceived the idea of employing it as fuel for automobiles. Naphthalene is very rich in carbon and its price is only one-fourth that of gasoline, but its employment as a carbureter presents a number of difficulties which automobile engineers are now endeavoring to overcome. As naphthalene (C₁₀H₈) contains more carbon than even benzol (C₆H₆)—93.7 per cent in place of 92.3 per cent—its complete combustion is a matter of some difficulty. In the air it burns with a very smoky flame and deposits much of its carbon as soot. Yet it requires less air than benzol requires for complete combustion. Naphthalene is a solid at ordinary temperatures. It melts at 174½ deg. F. and boils at 424½ deg. F. In order to produce an explosive mixture of naphthalene and air the naphthalene must be heated above its melting point. The carbureting can then be effected by methods similar to those used for gasoline and other liquids. For this purpose the carbureter is usually heated by the exhaust gases. The air should also be heated before it comes into contact with the naphthalene. The quantity of air admitted to the cylinder should be regulated very carefully, as the slightest deficiency prevents complete combustion. The motor should be run with a volatile fuel until the carbureter has become heated and the naphthalene melted. These conditions make the employment of naphthalene troublesome, but they do not destroy its great advantage in point of economy. In comparative tests made in 1907 naphthalene produced nearly one-third more power than an equal weight of carbureted alcohol.

ELECTRICAL NOTES.

The use of accumulator cars on main lines has lately begun to assume some importance, and some particulars of experience gained during ten years' trials on the main lines of the Palatinate Railways, which are given in the Bulletin of the International Railway Congress, should not be allowed to pass unnoticed. The chief conclusion to be drawn from the experience of the Palatinate Railways, extending over a number of years, is that an accumulator motor car service can be economically successful if the battery is well and carefully maintained, and if the current can be generated at a cheap rate.

The question of improving the load factor of central stations by utilizing the energy during the hours of low load for carrying out electro-chemical and electro-metallurgical processes was discussed at a recent meeting of the American Electro-chemical Society. The conclusion was arrived at that for many electro-chemical processes it would not pay to work intermittently or even with a reduced load for certain hours. On the other hand, intermittent working in the case of small electric furnaces, such as will probably soon be used to a large extent in steel works and foundries, would be easily possible. A case was cited of a Swiss steel plant, where energy was supplied at rates below the ordinary power rates during certain hours for working the electric furnaces.

The *Elektrotechnische Zeitschrift* gives a description of a 2,000-horse-power three-phase motor which the Felten Guillaume Lahmeyerwerke have recently erected at the iron and steel works in Völklingen. This motor runs at 100 revolutions per minute with 5,000 volts pressure and a frequency of 50, and can be used alone or in conjunction with a 3,000-horse-power gas engine for driving the preliminary rolls; the finishing rolls are driven by ropes from the preliminary rolls. The motor is provided with two bearings, which are fixed on a common bed-plate, and its spindle is at one end connected to the mill, while the other end is fitted with a rope wheel. The stator winding is three-phase, and is imbedded in mica tubes, but the rotor winding is two-phase. Starting is effected by means of a liquid starter provided with short-circuiting contacts.

It is stated in a consular report that two wireless telegraphy stations are to be established permanently at Algiers and Oran, the latter being erected by the Admiralty, the former by the Postmaster-General. The Oran station may accept private messages in time of peace, but it is established primarily as a means of communication in time of mobilization. The Algiers station will be situated at Fort de l'Eau, some 10 miles east of the town, on the bay, the station at Mustapha being done away with. It will be open to all private telegrams, and will consequently be able to communicate with passing steamers. It will communicate direct with Port Vendres and the Eiffel Tower. Besides these two principal stations, which are soon to be in working order, secondary stations will be established at points not yet fixed and connected with one of the two head stations.

An interesting feat in long-distance telegraphy was recently performed in London over the lines of the Indo-European Telegraph Company between England and India, when messages were sent direct without retransmission to the Indian terminals of the system. The lines of this company run from London to Lowestoft on the east coast, then by submarine cable under the North Sea to Emden, giving way to an over-land stretch passing through Berlin, Warsaw, Odessa, to Kertch, where another submarine section carries the extension by three cables across the Straits, picking up the land lines again to Tiflis and Tabriz to Teheran, making a total length of 3,800 miles. Until recently this was the eastern terminal of the line, but a new section has since been built, carrying the service on from the Persian capital to Kurrachee, representing an additional 1,574 miles, thus bringing the total length of line up to 5,374 miles. Between London and Teheran ten automatic repeaters were in the circuit, while in the extension there are three more, making thirteen repeaters distributed along the whole stretch of line. For the purposes of the demonstration, messages were sent direct between London and Kurrachee at an average speed of forty words per minute. These proving satisfactory in either direction, various other Indian lines working with automatic repeaters were added to the London-Kurrachee trunk, connecting up Madras and Rangoon in Burma respectively, thereby increasing the length of line up to 6,900 and 7,700 miles respectively. The same transmission speed was maintained with equal success, and it may be mentioned that both the latter distances constitute records in direct telegraph working. The value of such through communication and automatic repeater operation was strikingly shown on the occasion of the death of the late Shah of Persia, which was known in London two minutes after it was announced in Teheran, 3,800 miles distant.

ENGINEERING NOTES.

According to The Practical Engineer, the time required for effecting a weld is 24 seconds for each inch of diameter, the generator power being 5 horse-power for rods $\frac{1}{4}$ inch diameter; 16.2 horse-power for $\frac{1}{2}$ inch; 55 horse-power for 1 inch; 112 horse-power for $1\frac{1}{2}$ inch, and 170 horse-power for 2 inches. For rectangular sections the power required is from 25 to 50 per cent greater, and the time 12 to 50 per cent greater. It takes from two to three times as much power to weld copper as it does iron, but the time required for iron is longer, being about 40 seconds per inch of diameter.

A prospector sent to the south of India to look for coal is reported to have made an important discovery, though not quite along the lines of his search. He is reported to have discovered "tantallite" in a small hill tract west of Trichinopoly in the Kadavur Zemindary. The place lies some seven miles north of the Vayampatti, South Indian Railway station, in the midst of a populous district, but one which had never been thoroughly prospected before. Arrangements are, it is said, being made to have large samples of the ore extracted for the purpose of analysis. This is said to be the first find of tantallite in India.

The total iron mined in Great Britain in 1907, according to the amended returns, was 15,731,604 long tons. Ore imported was 7,641,934 tons, making a total of 23,373,538 tons. Exports were 21,877 tons, leaving a net balance of 23,351,661 tons. To this is added 576,856 tons of pyrites residue, and 1,195,242 tons of forge and mill cinder, making a total of 25,123,759 of material for the furnaces. The pig iron made was 10,114,281 long tons, showing an average of 2.47 tons ore used for one ton of pig. The coal used for all purposes at the blast furnaces—including coal converted into coke—was 21,119,547 tons, an average of 2.09 tons of coal to one ton of pig iron.

What is probably the most stupendous attempt ever made by man to regulate, by artificial means, one of the forces of nature is the proposed use of Lake Superior as a storage reservoir. It has been several times pointed out that with proper regulating works at the outlet of Lake Superior it would be possible to greatly reduce fluctuations in level of the other Great Lakes. At present the general effect of the works hitherto carried out at the Sault—both those for the improvement of navigation and those for the development of water power—is to lower the general level of Lake Superior. But by the comparatively simple process of placing regulating works at the outlet of the lake, its level could be held continually at a high point, and the enormous area of the lake would thus be available to raise the level of the water in the lower lakes during dry seasons of the year. To make possible these controlling works, however, it will be necessary to condemn the water power companies now operating there, or at least compel their operation under restrictions. A bill was introduced in Congress, on January 5th, appropriating \$250,000 toward the expense of condemning the water power properties. It is probable, however, that by extending the regulating works over the free channel to a sufficient extent the interference with the present water power plants could be made comparatively small.—Engineering News.

Tourists in the region of Mont Blanc usually have a hard climb of several hours to make before reaching the high points which are noted for the remarkable views over the mountains and glaciers, and this is somewhat of a drawback to the pleasure of these excursions, not to speak of the large amount of time which is needed. However, one of the most celebrated sites, the great glacier of the Mer de Glace, can now be reached by a mountain railroad which has been recently built, and it was first started for service during the last season. On foot or on mule-back one must count half a day to mount to the Mer de Glace and return to Chamonix, the starting point of these excursions, but the ascent can now be made in one hour. The new line starts from the Chamonix railway station, where connection is made with the electric railroad, and it winds up the mountain for a distance of 3.3 miles, the difference of level being 3,170 feet. The Mer de Glace station lies at an altitude of 6,320 feet in round numbers. A steep gradient of 22 per cent is used on a good portion of the line, which is single track with a rack-rail between the road rails. By the use of the Strub rack-rail, which employs a rail head, a clamp brake under the head can be employed to hold down the car. A small steam locomotive on the Winterthur system is used, and there are five of them in service. They weigh about 18 tons empty and 24 tons in service. Two pinions for the rack are mounted on each locomotive. Among the various brakes there is one which is thrown on by a ball-governor when above speed. The present locomotives are rated at 250 horse-power, and they usually take a train of two passenger cars holding 60 persons each. The passenger cars are pushed up the grade by the locomotive.

TRADE NOTES AND FORMULÆ.

Preserving Fluid for Embryos and Delicate Tissues.—I. 2 to 2½ parts of bichromate of potash, part sulphate of soda, and 100 parts of distilled water. II. 140 parts of sea salt, 20 parts of alum, 0.3 part of sublimate of mercury, 250 parts of water.

Rubber Substitute.—According to a patented process a substance resembling caoutchouc or gutta percha is made by mixing gelatine, bichromate of potassium and glycerine and molding the mass thus obtained. The constituents are brought into use in an anhydrous condition, to prolong the action of the bichromate of potassium on the gelatine; by heating, the chemical action can be increased or decreased.

Kefir in tabloid form can be made by adding the characteristic ferment to the skimmed milk and while continuously stirring heating it to 102 deg. F. until about 30 per cent of the caseine is dissolved. The milk thus transformed is sterilized at 15.8 deg. F. Cocoa butter, milk sugar and cane sugar are added also some bicarbonate of soda, citric and lactic acids, the whole well mixed and pressed into tablets. For use, they are immersed in water, in which they gradually dissolve.

A cement that withstands boiling water and red heat is made from 1,000 parts of dry, powdered lime or clay, 80 parts of fine iron filings, 40 parts of manganese, 20 parts of common salt and 20 parts of bones thoroughly mixed with water to a paste and used at once. The surfaces to be cemented are first dried at a slowly rising heat, and then raised to a bright red heat, the cement becomes very hard and withstands equally well boiling water or a bright red heat.

Copying Pencils.—A mass adapted for red, yellow, blue, and green copying pencils is obtained by making an intimate mixture of 1 part each of slaked lime, with 2 to 3 parts of a cochineal and borax mixture or 2 to 3 parts of logwood extract and chromate of potash or 2 to 3 parts of indigo extract, or 2 to 3 parts of fustic extract, or 2 to 3 parts of the last two mixed. To make copying pencils from such mixture mix them with mineral wool, pulverized hard soap, and a solution of ox-gall and soap and press them according to the method practised in manufacturing lead pencils, in molds, or through perforated plates.

Composition Containing Nitrocellulose.—Nitrocellulose is dissolved in acetate of amyl and amyl alcohol, the product, according to the quantity of solvent used, having the consistency of varnish or of a stiff paste. For varnish consistency 100 parts of nitrocellulose, 400 parts of acetate of amyl, and 400 parts of amyl alcohol are required. A stiff paste is obtained with 100 parts of nitrocellulose, 150 parts of acetate of amyl and 150 parts of amyl alcohol. The varnish-like product can be used for the decorative coating of wood, leather, papers, etc., and the paste for the production of artificial leather, leather cloth, etc. The compositions may be used alone or combined with coloring substances, or with china clay, oxide of zinc, linseed oil, tannic acid, etc.

Jetoline, black, washable marking ink, is made according to Jacobsen's directions as follows: I. Copper solution: 8.52 parts of crystallized chloride of copper, 10.65 parts chloride of soda, and 5.35 parts of chloride of ammonia are dissolved in 60 parts of distilled water. II. Aniline solution: 20 parts of hydrochlorate of aniline dissolved in 30 parts of distilled water, add to this 20 parts of a solution of gum arabic (1 part gum and 2 parts water), and 10 parts of glycerine, mixing well. 4 parts of the aniline solution mixed with 1 part of the copper solution gives a greenish fluid, which can be used directly for marking linen, but can be kept good for only a few days, for which reason it is necessary to keep fluids I and II separate and mix them only shortly before use. The marking appears at first pale green on the fabric, but turns black after prolonged exposure to the air; by steaming it can be turned black immediately.

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